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TOBACCO CUTWORMS

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Bureau of Entomology

UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

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GENERAL CONSIDERATION OF TOBACCO CUTWORMS

Tobacco is one of those crops, grown in plant beds and transplanted to the open field, which are especially vulnerable to cutworm attack. Agricultural practice has accentuated its liability to injury by supplying conditions in the preceding crop (clover, grass, or weeds) which favor the multiplication of cutworms. With some types of tobacco it is desirable that all of the plants in a field ripen at about the same time. In such cases cutworm damage at transplanting time may be unusually important.

Cutworms differ in their method of attack and in the degree to which the cutting habit is developed. Thus *Sidemia devastator*

[1] The investigation reported in this bulletin was conducted as a project of the then existing division of Southern Field Crop Insect Investigations. The writer wishes to express his appreciation of the helpful attitude shown by A. C. Morgan, under whose direction the investigation was carried on. Several correspondents have given important assistance, especially C. N. Ainslie, J. U. Gilmore, D. C. Parman, and J. D. Mitchell. The authorities on insects in the Taxonomic Division of the Bureau of Entomology and in the National Museum have also rendered indispensable service. H. G. Dyar has been particularly helpful, and many of the data on the distribution of the species have been derived from an examination of the collections in his charge. Carl Heinrich has been of the greatest service in connection with the studies on larval anatomy. In the determination of the fungous diseases in the large number of larvae submitted to him, Alden T. Speare has made an important contribution. It is a pleasure to acknowledge the assistance given in a multitude of ways by the associates of the writer at the Clarksville laboratory. The writer wishes to express his appreciation of the willing and efficient service rendered by the bureau librarian, Miss Mabel Colcord. For illustrations the writer is indebted to the following: To H. B. Bradford for the drawings in Figure 4, D and E; Figures 8, 9, and 10; Figure 13, A and B; and Figures 14, 17, 18, and 19; to Joseph D. Smith for the drawings in Figure 4, A–C, F–J, and Figure 15, A–D; to W. N. Dovener for the drawings of moths in Plate 2 and Plate 3; and to G. G. Ainslie for two photographs of eggs (pl. 4, B and C).

feeds exclusively on the roots and adjacent stems of plants, whereas most species feed upon stems and foliage above ground; *Feltia annexa* has developed a very characteristic habit of partially severing the leaves of large tobacco plants; and some species, such as *Euxoa messoria*, *Porosagrotis vetusta*, and *Lycophotia saucia*, have the climbing habit and sometimes feed extensively upon the buds and foliage of trees and shrubs. The restless destructiveness often shown by larvae of *Agrotis ypsilon* may be compared with the more conservative attack of larvae of *Feltia gladiaria* or of larvae of *Prodenia ornithogalli*. The latter often feed upon foliage without resorting to the cutting habit.

Some species, such as *Feltia annexa*, *Euxoa messoria*, and *Chorizagrotis* (*Euxoa*) *auxiliaris*, oviposit nearly or quite exclusively in cultivated fields, but cutworm damage is usually most severe where tobacco follows clover or grass of several years' standing. Old pastures are also a prolific source of trouble when followed by tobacco. Cutworms may occur in large numbers in such forage crops without attracting attention, and usually they are able to maintain themselves indefinitely after the land is plowed. In rare instances such hordes of larvae are produced that they devour every green thing over large areas; however, a greater aggregate loss is caused by the much less spectacular and often very local depredations of these larvae which occur every season.

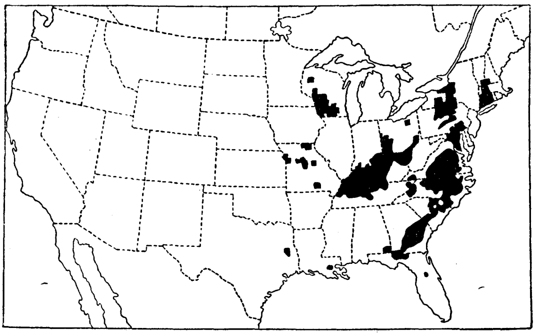

FIG. 1.—Outline map of the United States showing the tobacco-growing regions

Twenty-two species of cutworms have been taken feeding upon tobacco in the field and are properly included in this bulletin. Three other common species are also included because they are general feeders and have been collected in tobacco-growing regions (fig. 1), making it highly probable that they will be found to injure this crop. Following are the species:

Agrotis ypsilon Rott.
Agrotis badinodis Grt.
Agrotis c-nigrum L.
Agrotis unicolor Wlk. (*clandestina* Harr.).
Chorizagrotis (*Euxoa*) *auxiliaris* Grt.
Euxoa bostoniensis Grt.
Euxoa messoria Harr.
Euxoa tessellata Harr.
Feltia annexa Treit.
Feltia ducens Wlk.
Feltia gladiaria Morr.
Feltia malefida Gn.
Feltia subgothica Haw.
Feltia venerabilis Wlk.
Lycophotia (*Peridroma*) *infecta* Ochs. (*incivis* Gn.).
Lycophotia (*Peridroma*) *saucia* Hbn.
Parastichtis (*Amathea*) *bicolorago* Gn.
Polia (*Mamestra*) *legitima* Grt.
Polia (*Mamestra*) *meditata* Grt.
Polia (*Mamestra*) *renigera* Steph.
Porosagrotis vetusta Wlk. (*muraenula* G. & R.).
Prodenia dolichos Fab. (*commelinae* S. & A.).
Prodenia eridania Cram.
Prodenia ornithogalli Gn.
Sidemia (*Hadena*) *devastator* Brace.

In this general consideration of tobacco cutworms those observations are recorded which have a general bearing on the corresponding topics in the detailed treatments of the various species.

DISTRIBUTION

The data on distribution are still too meager to permit of exact delimitation of the range of tobacco cutworms, and the truth is frequently obscured by records of the occurrence of the volant adults far out of their real habitat, but as our knowledge of the distribution of the larvae increases it will be possible to define more clearly the true range of the species. Enough is now known, however, to permit of the statement that these insects conform rather closely in their distribution to the life zones of Merriam (*45*).[2]

The following groups of species are to be distinguished:

(1) The Transition and Upper Austral group. This group includes the following 15 species: *Feltia ducens*, *F. subgothica*, *F. gladiaria*, *F. venerabilis* (probably), *Porosagrotis vetusta* (probably), *Euxoa messoria*, *E. tessellata*, *E. bostoniensis* (probably), *Sidemia devastator*, *Agrotis unicolor*, *A. badinodis*, *A. c-nigrum*, *Polia legitima* (probably), *P. renigera*, and *Parastichtis bicolorago*.

(2) The Lower Austral group. This group includes the following five species: *Feltia annexa*, *F. malefida*, *Prodenia ornithogalli*, *P. dolichos*, and *P. eridania*.

(3) The western or arid-region group. This group includes but one species, *Chorizagrotis auxiliaris*.

(4) The eastern or humid-region group. This group includes *Lycophotia infecta* and *Polia meditata*. *Agrotis ypsilon* also seems to have its metropolis in the northern part of this area.

(5) The cosmopolitan group. This group includes two species, *Lycophotia saucia* and *Agrotis ypsilon*, and might also include *Agrotis c-nigrum*.

LIMITING FACTORS IN THE DISTRIBUTION OF MULTIPLE-BROODED SPECIES

The metropolis of most multiple-brooded species is in the warmer latitudes. This is largely due to their low resistance to cold in all their stages and to a tendency to pass the winter as pupae. Four of the multiple-brooded species have their metropolis in the north. Two of these, *Polia renigera* and *Agrotis c-nigrum*, hibernate as larvae. Two cosmopolitan species, *Lycophotia saucia* and *Agrotis ypsilon*, pass the winter as pupae. Possibly these last species have become adapted to pupal hibernation owing to boreal origin.

On the northern frontier of the range of a multiple-brooded species only a small proportion of the last brood of moths may succeed in producing overwintering progeny. This is due to the fact that each successive brood during the season emerges over a progressively longer period, with the result that in the later broods the period of emergence is so extended that the progeny of the earlier moths produce other moths the same season too late for successful reproduction, while the progeny of the late-emerging moths are killed by the cold before reaching the pupal stage.

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[2] Reference is made by italic numbers in parentheses to "Literature cited," p. 176.

This condition is exemplified in the case of *Feltia annexa*. About the earliest date of pupation which will result in overwintering pupae in this species is October 4. Pupae formed prior to this date produce moths the same season. For pupation after October 4 it is necessary that the parent moths shall not emerge earlier than about August 3. From somewhat meager data collected in 1913, 1914, and 1915 (1914 being unusually cold in November and the other two years mild) the writer concludes that the latest date of emergence which will allow the progeny time to reach pupation before being killed by the cold is prior to September 14. If this variable date is placed at September 10, the period of emergence for successful reproduction is then limited to the time between August 3 and September 10. Applying these restrictions to the diagram shown in Figure 2, in which the dates of emergence of 490 reared moths are recorded, it is found that 43 per cent of this brood emerged too late for successful reproduction. If this period had terminated only a few days

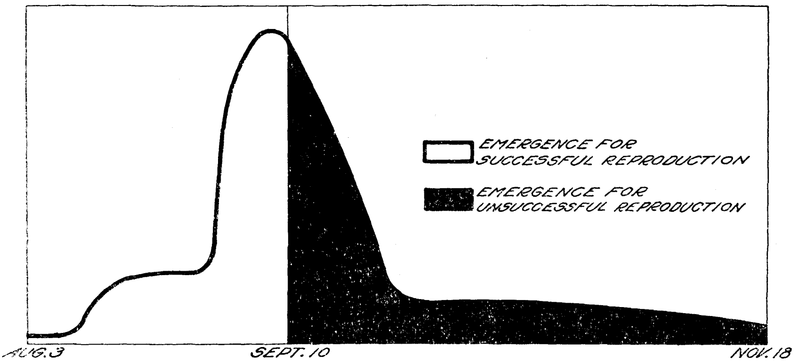


FIG. 2.—Emergence of last-brood moths of *Feltia annexa*

earlier, the percentage of loss would have been very materially increased.

Even after this portion of the progeny of the last-brood moths has reached the pupal stage, the pupae have, in most cases, a very poor chance of surviving the winter in the latitude of northern Tennessee. On several occasions the writer has allowed larvae of *Feltia annexa* to pupate by hundreds in the soil in sheltered situations outdoors, but only rarely has a single pupa survived the winter under these conditions. These species, with some exceptions already noted, are not fitted to withstand much cold in any of their stages.

Only two multiple-brooded species, *L. saucia* and *A. ypsilon*, and one obscure single-brooded species, *Polia legitima*, have their metropolis in the North and hibernate as pupae. Pupal hibernation seems to be a limiting factor of importance in the northern distribution of all cutworm species.

Powerful repressive forces other than cold are operative against multiple-brooded species in the far South, or they would become an overwhelming pest in tropical latitudes. It is probable that these species, at a higher range of temperatures, meet with difficulties similar to those experienced by single-brooded species. Woodhouse and Fletcher (*83*) state that *Agrotis ypsilon* aestivates in Egypt, although it is not recorded as doing so in the United States.

FACTORS INFLUENCING THE SOUTHERN DISTRIBUTION OF SINGLE-BROODED SPECIES

A species which is single-brooded in Canada is likewise single-brooded in Tennessee. These species tend to be of northern distribution, and the higher average temperature encountered as they advance into more southern latitudes tends to shorten the time necessary for the completion of the cycle of development. In order that the various features of the seasonal history may be fixed as to seasonal occurrence, the cycle of development must be made to occupy a full year. This is accomplished by interpolating a period of retarded development, which is prolonged as the species advances southward to compensate for the tendency toward acceleration.

This periodical slowing down of development occurs in all the single-brooded species included here in so far as their habits are known, and also occurs in many other species. Data covering the stage in which retardation occurs and the approximate time spent in a quiescent state in each species are given below:

Feltia ducens, 4 months as larva; *Feltia subgothica*, 4 months as larva; *Feltia gladiaria*, 5 or 6 months as egg and larva; *Agrotis badinodis*, 5 months as pupa; *Parastichtis bicolorago*, 6 or 7 months as egg and larva; *Polia legitima*, 9 months as pupa; *Polia meditata*, 4 months as larva; *Euxoa messoria*, 5 to 7 months as egg. In addition, it is known that the moth of *Chorizagrotis auxiliaris* lives several months before ovipositing.

One surprising result of this retardation is that, in several cases at least, emergence in Tennessee is distinctly later than it is in Canada. The main emergence of *Feltia ducens*, for example, is entirely over in Canada before it begins in Tennessee. This is apparently due to the fact that the larva aestivates for about four months in Tennessee.

Probably there is a definite limit to the period which a species may economically occupy in a quiescent state, both from the standpoint of survival during this period and from the standpoint of adjustment to its environment. These factors may tend to set a limit to the southern distribution of many single-brooded species.

Another peculiar phenomenon observed in larvae of *Feltia ducens* may have a general application among larvae of single-brooded species. One hundred and sixteen larvae were forced into abnormally early aestivation by keeping them in a warm greenhouse with an abundance of food. A flowerpot containing 40 of these larvae was removed to an unheated insectary on March 4, 1919, while 18 more were removed to the insectary on June 2. Three larvae were also removed from the greenhouse on July 20 and placed in an ice box having an average temperature 19° F. below that of the insectary.

When the final examination of these experiments was made November 1, 1919, it was found that 6 larvae from the greenhouse, 11 from the insectary, and 1 from the ice box were still aestivating, and these larvae continued in this state until they were killed by the cold in December. Of 201 larvae collected in April and May and kept in the insectary but 1 larva remained on November 1.

Apparently, in the case of a considerable portion of the larvae, too high a temperature during the period of growth brought about a rapid development which resulted in a precocious aestivation which outstripped some independent development in the larva necessary to pupation, so that these larvae lay aimlessly in their cells for months after the usual time for pupation in this species and were ultimately killed by the cold. This would seem to indicate that too high a temperature during the period of growth may tend to place a limit to the southern distribution of some at least of the single-brooded species. The normal period of retarded development in these species is probably a less drastic manifestation of the effect of heat on the interplay of growth and metamorphosis.

COLORATION OF LARVAE

In the gradual divergence of two closely related species of larvae, appreciable differences in coloration appear before specific variations in the structural characters are discernible, and for this reason coloration is often utilized as a means of distinguishing species of larvae. Thus the species of Prodenia and of the Euxoa group possess a baffling generic homogeneity of structure, but all have fairly well-marked peculiarities of color. But this plasticity of the coloration, which renders it highly serviceable in distinguishing the species, extends also, in a less degree, to the individuals within the species, rendering it necessary to utilize colorational characters with discretion. Thus *Prodenia ornithogalli* may vary in general color from jet black to pale gray, although certain details, such as the coloration of the head, remain constant.

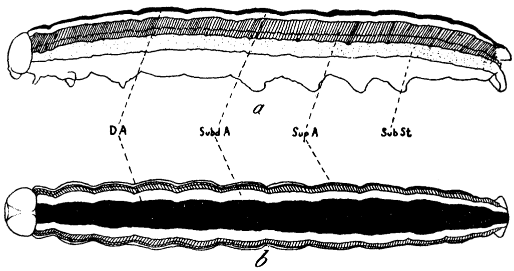


FIG. 3.—Colorational areas of larva: *a*, dorsal view; *b*, lateral view; *DA*, dorsal area; *SubdA*, subdorsal area; *SupA*, supraspiracular area; *SubSt*, subspiracular stripe

From the grublike coloration of *Sidemia devastator* to the gaudy striping of *Polia legitima*, one color pattern is traceable throughout nearly the whole series, although it is subject to various modifications, and gives strong evidence of having taken its origin from a striped larva with a coloration resembling that of *P. legitima*. (Fig. 3.)

On the dorsum is an area having a median pale line, usually bordered laterally by a paler line or stripes, or by a series of segmental black markings, or by a combination of these, and usually including tubercles I and II. This is the dorsal area, and the bordering lateral markings constitute the subdorsal stripe or subdorsal spots occupying the subdorsal area. Between the subdorsal area and the spiracles is the supraspiracular area. This bears a pair of indistinct, broken, pale, submedian lines between which the color may be paler than that on either side and the dorsal and ventral portions may differ in shade or intensity of coloring so that the area may be occupied by three narrow stripes; or may be nearly unicolorous; or the dorsal or ventral portion may present an intense shade of color which becomes progressively more dilute in succeeding areas. Below the spiracles is a pale subspiracular stripe. The pattern of coloration is given as it occurs on the abdomen. On the thorax these markings may be modified or obsolete. The prominently striped type of coloration, as exemplified by *Polia legitima* and *P. renigera*, is highly protective, the former species being very inconspicuous upon the slender grasses which are its normal food and the latter likewise when clinging in an extended posture to the weed litter on the ground according to its habit. Among those larvae which lead more concealed lives there is found a more uniform coloration that harmonizes better with the soil with which they are associated. In *Sidemia devastator* the pigmentation of the skin is much reduced owing to the more strictly subterranean habit of the species.

COLORATION OF HEAD SHIELD

The coloration of the head shield (fig. 4, A, B) usually consists of a gray, yellowish, or brown undercolor or ground color over which more or less fuscous or ferruginous shading is disposed in the form of a pair of curved submedian stripes, or arcs, which are sometimes absent; and more or less reticulation which may be fused in the ocellar region to form the ocellar stripe. This reticulation is occasionally absent and is sometimes replaced by fuscous flecks. The coloration of the head shield is very constant and should be carefully noted in describing larvae.

ANATOMY OF LARVAE

The primary object in making the following observations on cutworm anatomy has been to determine what structures offer readily available characters for separating the species. The writer's investigations have taken into account only the external features, with the exception of the mouth parts. At the end of this section is an outline for describing a cutworm. This outline is a presentation in tabular form of the characters which have been found of value in distinguishing species of cutworms and which might well be included in descriptions of these larvae.

GENERAL CUTWORM CHARACTERS

The cutworm characters are described in general as follows:[3]

Body long, moderately stout; tapering sharply anteriorly on the prothorax. at least; head rather small; spiracles conspicuous, elongate oval. Prolegs developed on abdominal segments 3, 4, 5, 6, and 10 in mature larvae; crochets uniordinal, arranged in a mesoseries. Primary setae only; IV and V on abdominal segments well separated, IV directly behind the spiracle except on abdominal segment 7, where it is caudoventral of the spiracle and somewhat closer to V; ninth abdominal segment with six setae, IV and V absent, I anterior to and nearly equidistant from II and III, on proleg-bearing segments (3 to 6) VII trisetose, unisetose on abdominal segments 7, 8, and 9, bisetose on first abdominal segment; prothorax with II^a above the level of I^a. I^c and II^c approximate, two setae only on prespiracular shield (IV and V), III absent; VI bisetose on prothorax, unisetose on meso- and metathorax. Head with frons broadly triangular, as wide as long, frontal setae well forward on the front; setae of posterior group well back on the head; lateral seta (L^1) remote from A^3. Adf^2 on or above the level of the apex of the front, and distinctly nearer to P^1 than to P^2. Interspace E^1–E^2 as long as F^1–F^a and usually distinctly longer. Puncture G^a between and distinctly posterior to the line of setae G^1 and O^3. Ocellus VI nearer to O^1 than to O^3. Apical papilla on first segment of

[3] This paragraph was drawn up in collaboration with Carl Heinrich, to whom the author wishes to express appreciation for his assistance. The original draft has been somewhat revised and amplified by the writer, who assumes all responsibility for any errors which may occur.

labial palpi conical, but little, if any, longer than the second segment. Body longitudinally marked with lines, stripes, or spots in the subdorsal, supraspiracular and subspiracular areas. Larvae cut the stems of plants.

Certain groups of species have apparently diverged from the parent stock within comparatively recent times and still bear the clear im-

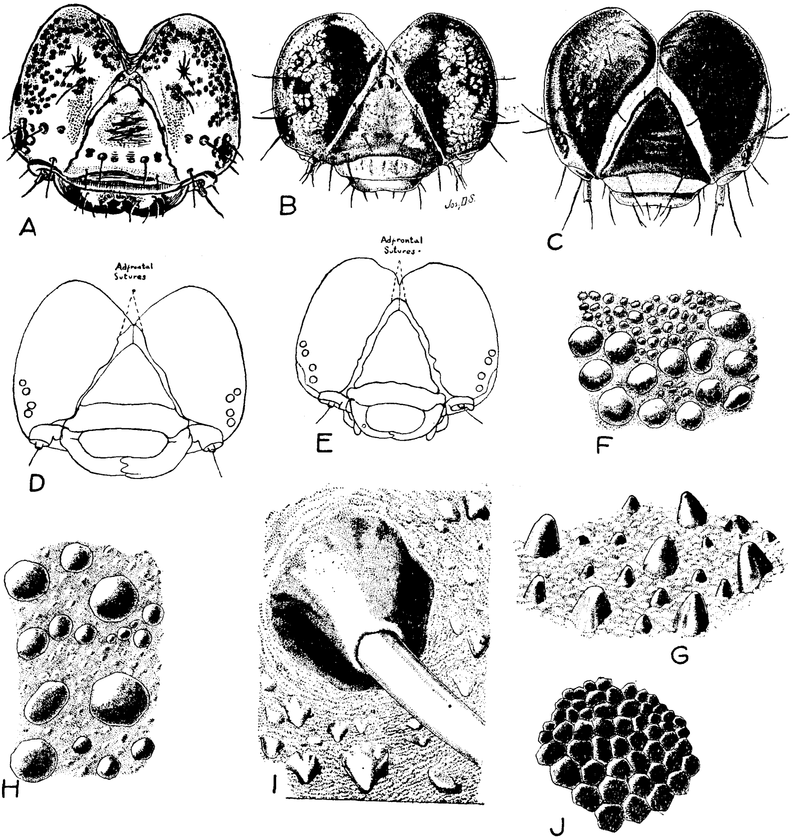


FIG. 4.—A, *Euxoa messoria,* head shield of larva, showing flecked type of coloration; B, *Feltia ducens,* head shield of larva, showing reticulated type of coloration; C, *Prodenia ornithogalli,* head shield of larva, showing black dorsal coloration and white adfrontal areas; D, *Feltia annexa,* head shield of larva, showing adfrontal sutures terminating in the occipital foramen; E, *Lycophotia saucia,* head shield of larva, showing adfrontal sutures terminating before reaching the occipital foramen; F, *F. ducens,* portion of skin of larva highly magnified, showing the strongly convex, isolated primary and secondary granules; G, *F. annexa,* portion of skin of larva highly magnified, showing the isolated, conical, retrorse primary and secondary granules; H, *Agrotis ypsilon,* portion of skin of larva highly magnified, showing the strongly convex, coarse, isolated primary and secondary granules; I, *Polia renigera,* portion of skin of larva highly magnified, showing one of the conical dorsal setigerous tubercles, the base of the coarse seta, and the isolated, irregularly conical granules; J, *F. gladiaria,* portion of skin of larva highly magnified, showing granules set contiguously, like blocks in a pavement, without secondary granules

press of the parent form. On this account the number of available structural characters for distinguishing closely related species of larvae is often greatly reduced and is sometimes apparently nonexistent. The three species of Prodenia furnish the best example of this condition, although the species of the Euxoa group might be cited with almost equal relevancy. Between rather distantly related species, however, positive structural characters for their identification are usually available.

PROPORTIONS OF THE BODY

The length, median breadth, and contour of the body should be recorded. In contour there are several types, such as, tapering from prothorax posteriorly, abdominal segments of about equal width throughout, broadest through abdominal segments 1 to 4, enlarged on mesothorax and eighth abdominal segment.

SKIN

The character of the skin (fig. 4, F–J) in each of the different species of larvae is practically constant and furnishes taxonomic characters of much importance, particularly when these are taken in conjunction with the character of the tubercles and other anatomical features. Larvae may be divided into two groups on skin characters, the first including those in which the skin appears nearly or quite structureless under a low power of the compound microscope and is called smooth, and a second in which the skin bears certain definite structural units and is said to be granulose. Those possessing the granulose type of skin may be again divided into two classes; one having the granules coarse and isolated (several types falling within this group) and the other having the granules much smaller and set contiguously like the blocks in a pavement. Although even the coarsest granules are not more than one-twentieth of a millimeter broad, with a little practice the character of the skin may be determined with a good hand lens.

Larvae with smooth skins include all of the species in which the adfrontal sutures do not reach the occipital foramen (see key to larvae), excepting *Polia renigera* and *P. meditata*, in which the skin is granulose. The species in which the adfrontal sutures terminate in the occipital foramen all have the skin granulose. Comparatively large setigerous tubercles are also invariably associated with a granulose skin.

A granulose skin, with some exceptions, is associated with a more subterranean habit than occurs normally among the smooth-skinned species, and all species which live in well-defined tunnels in the soil, with the exception of *Agrotis ypsilon*, have the skin pavement granulose. In some species the coarse, elevated granules are a part of the protective equipment of the larva. Thus in *Feltia annexa* these granules have been so modified as to retain a coating of dust on the larva, which lies in the soil with the dorsum exposed; and in *P. renigera* the contour of the head and body is less definite, owing to their being coarsely granulose.

The granulose skin found in all first-instar larvae of the group included here should probably be considered a specialization rather than a recurrence of a primitive character.

HEAD

The head furnishes characters of prime importance in the classification of larvae. There are some obvious variations in contour, as may be seen by comparing the head of *Lycophotia infecta* with that of *L. saucia*, but these are often obscure and difficult of description. Upon the extent to which the head is penetrated by the occipital foramen (fig. 4, D, E) the larvae may be divided into two large classes; one in which the penetration is such that the adfrontal sutures terminate in the margin or apex of the foramen and another in which these sutures terminate before reaching the occipital foramen. The width of the head is an important character, particularly

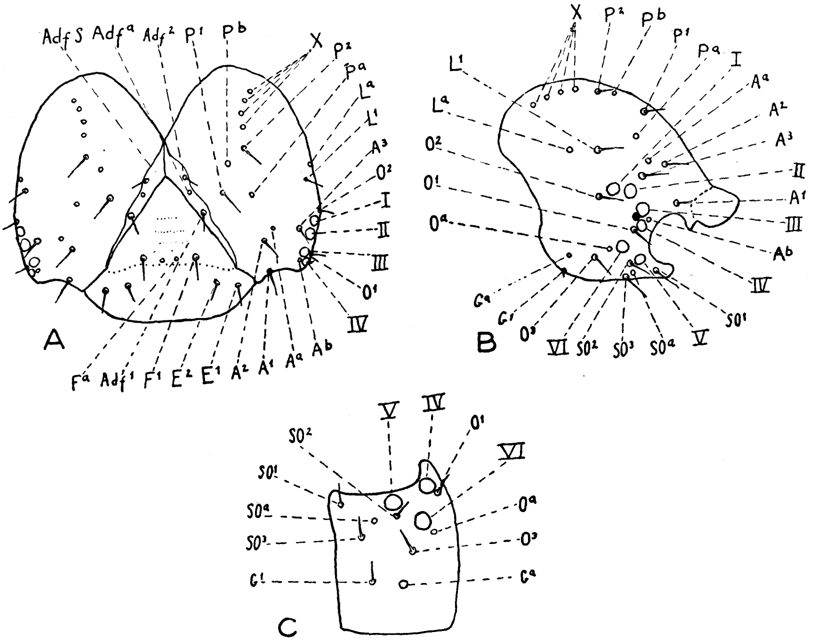


FIG. 5.—A, head shield of larva of *Feltia annexa*, dorsal view, showing arrangement of setae and punctures; B, head shield of larva of *Feltia annexa*, lateral view, showing arrangement of setae and punctures; C, head shield of larva of *Feltia annexa*, ventral view, left half, showing arrangement of setae and punctures.
Explanation of symbols used: A^1, A^2, A^3, A^a, anterior setae and puncture of head shield; Adf^1, Adf^2, Adf^a, adfrontal setae and puncture of head shield; *AdfS*, adfrontal suture; E^1, E^2, epistomal setae; F^1, F^a, frontal seta and puncture; G^1, G^a, genal seta and puncture of head shield; L^1, L^a, lateral seta and puncture of head shield; O^1, O^2, O^3, O^a, O^b, ocellar setae and punctures of head shield; P^1, P^2, P^a, P^b, posterior setae and punctures of head shield; SO^1, SO^2, SO^3, SO^a, subocellar setae and puncture of head shield; *X*, ultraposterior setae and punctures of head shield; I, II, III, IV, V, and VI, ocelli

in determining the larval instars, since it is but very slightly variable within the instar.

HEAD SETAE AND PUNCTURES

There are many positive differences in the arrangement of the head setae and punctures in the different species (fig. 5, A, B), with a strong tendency toward generic homogeneity, but it should be borne in mind in making use of these characters that there is frequently a rather large amount of individual variation in their relationships. Hence the examination of a considerable series of specimens is desirable before positive conclusions are drawn.

Similarity in the arrangement of the setae and punctures of the head seems to be to some extent a register of similarity in food habits, although ordinarily it is an indication of close relationship. Cases in point are seen in the resemblance in the arrangement of the setae and punctures in *Lycophotia infecta* and the species of Cirphis and in *Sidemia devastator* and the remotely related species of Agroperina. Furthermore, in the species included here, a wide departure from the usual arrangement is invariably associated with decided peculiarities in the mandibles.

ANTERIOR SETAE AND PUNCTURES

Anterior seta 1 is set near the base and about midway of the width of the dorsal process to which the mandible is attached; A^2 is posterior to A^1 and usually nearer to the margin of the front; A^3 is opposite ocellus II and usually not more than the width of the ocellus removed. Puncture A^a is between A^2 and A^3 and above the line connecting their bases, being decidedly above in all the species excepting *Sidemia devastator*. Puncture A^b is situated between ocelli III and IV and about on the line of their inner margins and shows but slight variation in position throughout the series of larvae here treated.

All of the larvae in which the adfrontal sutures do not reach the occipital foramen, with the exception of *Polia renigera*, have A^2 distinctly nearer to A^1 than to A^3. In *renigera* these are nearly or quite equidistant. In the species in which the adfrontal sutures terminate in the occipital foramen, A^2 is approximately equidistant from A^1 and A^3, or very slightly nearer to A^1, excepting in *S. devastator*, in which A^2 is slightly nearer to A^3.

OCELLAR SETAE AND PUNCTURE

In all the larvae but the species of Prodenia, O^1 is posterior to a line connecting the centers of ocelli IV and VI, but in *Polia legitima* the base of the seta is so near the line that it is included in the curve of the ocelli. In all cases O^1 is less than the ocellar width removed from ocellus IV, and ocellus VI is somewhat nearer to O^1 than to O^3. Seta O^2 is posterior to, and usually somewhat ventrad of, ocellus I and is less than the ocellar width removed, excepting in *Sidemia devastator*. Seta O^3 is ventrad of the other two, with O^1 forming the apex of an isosceles triangle or with the side O^1–O^2 the shorter, excepting in *S. devastator*, in which the side O^1–O^3 is the shorter. Puncture O^a is posterior to ocellus VI, less than the ocellar width removed, and nearer to the ocellus than to O^3.

SUBOCELLAR SETAE AND PUNCTURE

Seta SO^1 is situated near the apex of the ventral process to which the mandible is attached; SO^2 is set immediately posterior to ocellus V; and SO^3 is placed posterior to these and nearer to SO^2. In the species of Prodenia SO^2 is set slightly more posterior to ocellus V and toward ocellus VI than in the other species, being normally on a line with the outer margin of ocellus V. Puncture SO^a is distinctly anterior to a line connecting the bases of setae SO^2 and SO^3 and is approximately equidistant from these setae or somewhat nearer to SO^2 in all the larvae in which the adfrontal sutures terminate in the occipital sinus. In the opposing category the puncture is decidedly nearer to SO^3 than to SO^2, usually two or more times as near, excepting in the species of Polia and *Agrotis badinodis*. In the species of Prodenia, *A. c-nigrum*, and *Lycophotia infecta* the puncture is nearly or quite directly anterior to SO^3.

ADFRONTAL SETAE AND PUNCTURE

Seta Adf^1 is situated about midway between F^1 and Adf^2, being slightly nearer to Adf^2 in some of the species in which the adfrontal sutures terminate in the occipital foramen and somewhat nearer to F^1 in nearly all of the species in the opposing category. Adf^2 is on or somewhat above the level of the apex of the front and puncture Adf^a is somewhat nearer to Adf^2 than to Adf^1 in all the species, with the exception of *Sidemia devastator*.

POSTERIOR SETAE AND PUNCTURES

Seta P^1 is usually either distinctly nearer to Adf^1 than to Adf^2 or nearly or quite equidistant from the two. In a few species P^1 is distinctly nearer to Adf^2. Setae P^2 and Adf^1 are either approximately equidistant from P^1, or P^2 is somewhat the nearer. Puncture P^a is set very near the level of Adf^1 in all the species with the exception of *Lycophotia infecta*, *Polia legitima*, and *Sidemia devastator*, in which the puncture is distinctly above the level of the seta. Puncture P^b is situated between P^1 and P^2 distinctly nearer to P^2 and mediad of the line connecting their bases.

LATERAL SETA AND PUNCTURE

Seta L^1 is situated above A^3, with A^3 approximately equidistant from L^1 and A^2 in most species. In a few species L^1 is somewhat the nearer and in several others A^2 is distinctly the nearer. Puncture L^a is so situated posterior to L^1 that L^1 is somewhat nearer to L^a than to O^2 in nearly all species.

GENAL SETA AND PUNCTURE

Seta G^1 is situated on the ventral surface of the head and toward the median line in reference to O^3 and is uniformly short and weak, probably owing to the fact that it occupies a portion of the head which is retracted into the thorax upon occasion. Puncture G^a is situated between and distinctly posterior to the line of setae G^1 and O^3. Seta G^1 shows rather wide individual variation in its relationships with setae SO^3 and O^3. Thus in species in which SO^3 is distinctly nearer to G^1 than to O^3 there will be a certain percentage of specimens in which the two setae will be equidistant from SO^3.

FRONT AND ADFRONTAL AREAS

The adfrontal sutures terminate in the occipital sinus in the species of Feltia and Euxoa and in *Agrotis ypsilon*, *Porosagrotis vetusta*, and *Sidemia devastator*, while in the remaining species the sutures clearly terminate on the median line before reaching the sinus.

Correlated with the former condition are—

1. Front, measured on the median line from the upper margin of the epistoma, comprising 70 to 80 per cent or more of the total height of the head capsule.
2. Adfrontal setae 2 set distinctly less than twice their width apart from the apex of the occipital sinus.

Correlated with the latter condition are—

1. Front, measured on the median line from upper margin of epistoma, comprising 50 to 60 per cent of the total height of the head capsule.
2. Adfrontal setae 2 set distinctly more than twice their width apart from the apex of the occipital sinus excepting in *Lycophotia saucia* and the species of Prodenia.

With the exception of *Parastichtis bicolorago*, the front, measured at the dorsal margin of the epistoma, is as broad as high and usually distinctly broader than high. The punctures F^a are usually on the line of setae F^1 but are distinctly below this line in some species. In most species the interspace between the seta and its adjacent puncture is somewhat greater than the interspace between the two punctures and in some cases the latter is but half the former. The interspace E^1–F^2 is greater than F^1–F^a in nearly all of the species. Adf^2 is set on or above the level of the apex of the front, and is distinctly above the level of P^1 in all species excepting *Agrotis ypsilon*, *Polia legitima*, *P. meditata*, *Agrotis badinodis*, *A. c-nigrum*, *Lycophotia infecta*, *Prodenia dolichos*, *P. eridania* and *Sidemia devastator*.

OCELLI

The ocelli show no important variation in arrangement from that indicated in Figure 5, B. There is usually a callosity extending between I and II so that I is directed more or less posteriorly. Ocelli III and IV are approximate in *Prodenia ornithogalli*, *P. dolichos*, *P. eridania Agrotis c-nigrum*, *A. badinodis*, *Polia legitima*, *Lycophotia saucia*, and *Parastichtis bicolorago*.

MANDIBLES

The mandibles are wedge-shaped in longitudinal section, with the outer surface convex and the inner concave, and are provided ventrally with a subglobular condyle and dorsally with a shallow socket by which they are attached basally to the head shield. The mandibular socket may be reinforced ventrally by a process which is particularly noticeable in the species of Feltia. The inner margin usually bears five teeth which may be slightly crenulated, and there is a tendency in many species to have the teeth of the upper part of the cutting margin replaced by a straight or crenulated edge. This crenulated area is conspicuous in the species of Prodenia and Agrotis. At least the first two or three ventral teeth alternate with curved internal ridges having their origin about the mandibular socket. On the exterior surface near the ventral margin and nearer the base than the cutting margin are two bristles directed inward, the shorter anterior. These occupy a portion of the broad, shallow antennal scrobe.

Mandibles of what may be called the ordinary type, as described above and shown in Figure 6, C, have various slight specific modifications, but there is another class of mandibles in which these modifications are conspicuous and furnish fairly constant characters for distinguishing the species. Mandibles of the latter type are found in *Polia legitima* (fig. 6, B), *Lycophotia infecta* (fig. 6, A), *Agrotis c-nigrum* (fig. 6, E), *A. unicolor* (*clandestina*) (fig. 6, D), *A. badinodis* (fig. 6, F), *Sidemia devastator* (fig. 6, G), and the species of Prodenia.

In examining the mandibles it should be borne in mind that their outline and general appearance vary decidedly according to the angle

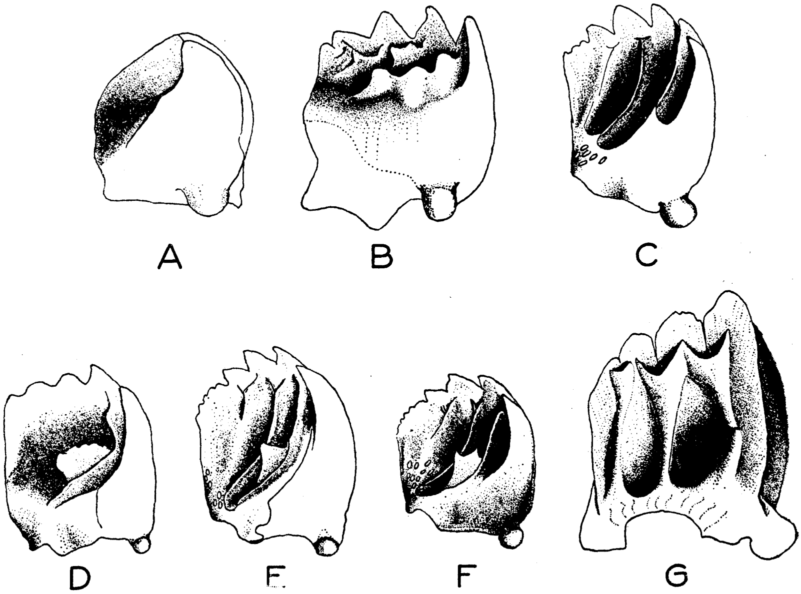


FIG. 6.—Mandibles of larvae, showing structure: A, *Lycophotia infecta;* B, *Polia legitima;* C, *Feltia ducens;* D, *Agrotis unicolor;* E, *A. c-nigrum;* F, *A. badinodis;* G, *Sidemia devastator*

at which they are viewed. In making the drawings for Figure 6 the point of view has been kept as uniform as possible.

LABRUM

The labrum does not vary greatly from the form shown in Figure 7, A, and the arrangement of the setae is essentially as there shown, except that M1 and M2 are more nearly in a transverse line in *Agrotis badinodis* and *Polia renigera* than is shown in the figure.

The apical notch is subject to considerable individual variation, and its character is sometimes difficult to determine on the larva, but the species may be separated rather sharply on this character into two groups; one in which the labrum is but moderately emarginate (fig. 7, C, *a*), and another in which it is strongly emarginate (fig. 7, C, *b*). The latter includes *Parastichtis bicolorago*, *Polia renigera*, *Agrotis badinodis*, *Porosagrotis vetusta*, and *Lycophotia infecta.* The species of Prodenia are particularly variable in this regard. The emargination is more acute in *L. infecta* than in any of the other species.

The labral punctures show slight variation in position throughout the series.

EPIPHARYNX

The epipharynx (fig. 7, B) occupies the ventral (oral) surface of the labrum. It is usually clothed sparsely throughout with weak hairs, rarely with short spines. The three setae situated on each side near the anterior margin are short and stout in all the species, with the exception of *Lycophotia infecta*, in which they assume the character of long coarse bristles. These setae are subject to considerable individual variation in shape, length, and direction with regard to the margins of the part, but seta 1 is pointed, and often seta 2, and seta 3 is usually larger than the others and blunt. In a few species seta 2 projects beyond the adjacent margin and in *L. infecta* both 1 and 2 exceed the margin distinctly. These setae glide over the outer face of the mandibles and may serve to prevent food from working up over them. The rods are longer in some species than in others but show considerable individual variation. They show no important variation in form. The epipharyngeal shield is represented by a rather narrow thickened margin about and particularly above the median apical emargination of the epipharynx.

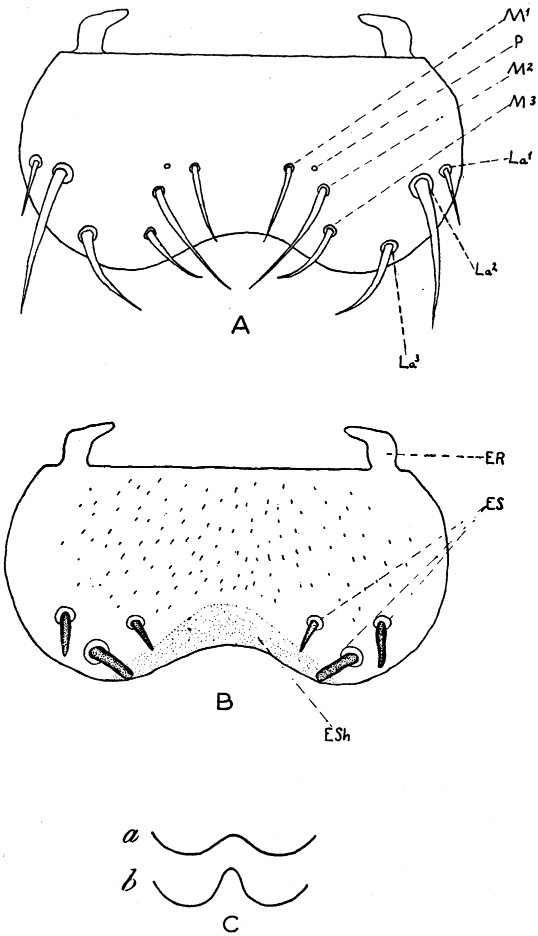


FIG. 7.—A, labrum of larva: M^1, M^2, M^3, median labral setae; *P*, labral puncture; La^1, La^2, La^3, lateral labral setae. B, epipharynx of larva: *ER*, epipharyngeal rod; *ES*, epipharyngeal setae; *ESh*, epipharyngeal shield. C, anterior margin of labrum of larvae: *a*, moderately emarginate; *b*, strongly emarginate

SUBMENTUM

There is no important variation in the submentum from the form shown in Figure 8, A, although the proportionate length and breadth vary somewhat in the different species and there is a similar variation in the antero-posterior position of the setae.

MAXILLAE

The boundaries of some of the parts of the maxillae are often obscure, making exact comparisons difficult, but differences occur in the comparative lengths of the cardo, stipes, and palpiger in the different species. The three setae on the first joint of the maxillary palpi usually have the form of coarse setae. (Fig. 9, B.) In *Polia legitima* and *P. meditata* they are short and stout, and in *Sidemia devastator* the setae have developed into broad, spatulate appendages. (Fig. 9, A.) From their position it would seem that the setae are

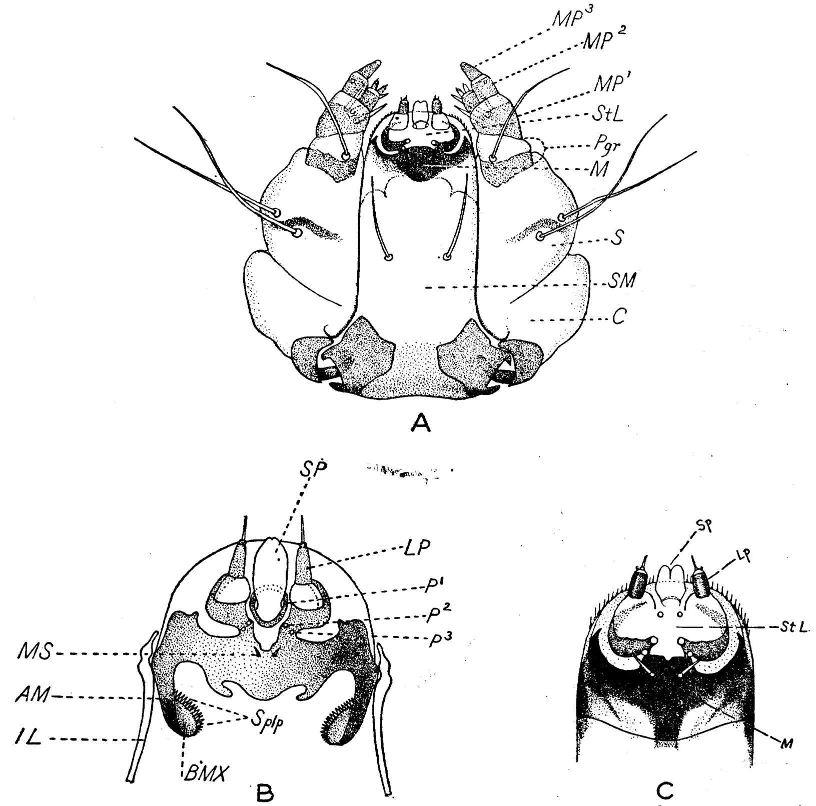


FIG. 8.—A, *Agrotis ypsilon*, labium and maxillae of larva: MP^1, MP^2, MP^3, segments of maxillary palpi; *Pgr.* palpiger; *S*, stipes; *C*, cardo; *SM*, submentum; *M*, mentum; *StL*, stipes labii. B, chitinous framework of mentum of larva: *Sp.*, spinneret; *LP*, labial palpus; P^1, P^2, P^3, punctures; *MS*, setae of mentum; *IL*, interstitial lamina between submentum and maxilla; *AM*, arm of mentum; *BMx*, blade of the maxillulae; *Splp*, spinelike processes on free margin of blade of the maxillulae. C, mentum and labial palpi of larva of *Agrotis ypsilon*: *Lp*, labial palpi; *M*, mntum; *Sp.* spinneret; *StL*, stipes labii.

used to clear the hypopharynx of food and to prevent food from slipping out from beneath the mandibles laterally.

MENTUM

The mentum (fig. 8, A, C) is the fleshy part occupying the ventral anterior portion of what from analogy might be called the lower lip. It bears subapically the labial palpi and spinneret and is supported by a chitinous framework (fig. 8, B) by which it is hinged laterally to the interstitial lamina which forms the lateral boundary of the submentum. The branches of this framework to which the above laminae are attached extend inward and upward at about right angles to the main portion as narrow blades, known as the arms of the mentum, which support the hypopharynx for nearly its entire length. On about the apical half of each of these supports there arises a single thin chitinous shield which constitutes the blade of the so-called maxillulae. It covers the lobes of the maxillulae laterally and its free margin is usually dentate, giving the effect of a series of teeth or spines.

The main features of the chitinous supporting framework are constant throughout the series of larvae here discussed and may be

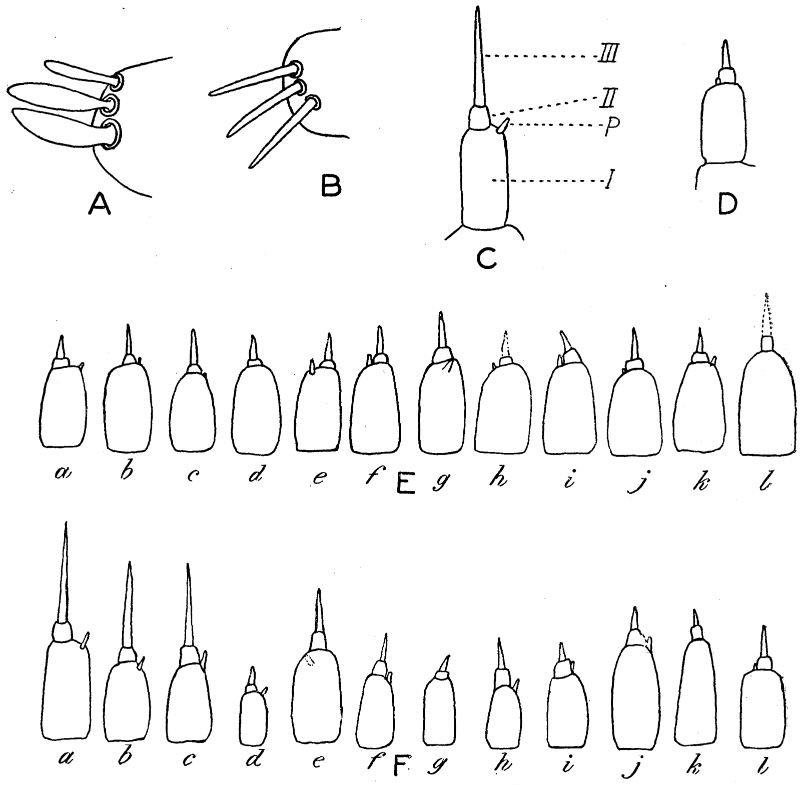


FIG. 9.—A, setae on first segment of maxillary palpus of larva of *Sidemia devastator*; B, same, of *Feltia annexa*. C, *Prodenia dolichos*, labial palpus of larva: I, II, and III, segments of palpus; *P*, papilla. D, *Lycophotia saucia*, labial palpus of larva. E, labial palpi of larvae: *a*, *Prodenia dolichos*; *b*, *P. ornithogalli*; *c*, *P. eridania*; *d*, *Parastichtis bicolorago*; *e*, *Polia legitima*; *f*, *P. renigera*; *g*, *P. meditata*; *h*, *Lycophotia infecta*; *i*, *Agrotis unicolor*; *j*, *A. c-nigrum*; *k*, *A. badinodis*; *l*, *L. saucia*. F, labial palpi of larvae: *a*, *Feltia ducens*; *b*, *F. annexa*; *c*, *F. gladiaria*; *d*, *F. venerabilis*; *e*, *F. malefida*; *F*, *Euxoa messoria*; *g*, *E. tessellata*; *h*, *E. bostoniensis*; *i*, *Chorizagrotis auxiliaris*; *j*, *Porosagrotis vetusta*; *k*, *Agrotis ypsilon*; *l*, *Sidemia devastator*. (Corresponding parts are all drawn to the same scale.)

divided into three divisions: (1) A more or less complete girdle about the spinneret, near the base of which are located the anterior pair of punctures; (2) a pair of supporting pieces partially surrounding the bases of the labial palpi, bearing on their inner apices the median and posterior punctures and connected anteriorly by a commisure with (3) the main portion, which bears medially on its anterior margin a pair of short, heavy mental setae and has its lateral margins produced inward to form the arms of the mentum, which are described above. The distance at which the mental setae are set apart varies in the different species, particularly when compared with the median punctures, and close-set setae are associated with a long spinneret. The punctures also vary among themselves as to the distance at which they are placed apart in the various species, usually being set progressively farther apart from front to back. The mentum merges posteriorly into the submentum as indicated in Figure 8, A.

LABIAL PALPI

The labial palpi (fig. 9, C, D) consist of a long, thick, cylindrical, basal segment, a second usually annular segment often not clearly demarked from the first but of much smaller diameter, and a third slender apical segment.

The main taxonomic features of the palpi are the relative lengths of the first and third segments and of the second and third segments. In species of Prodenia the third segment is as long as the first segment, while in no other species is it more than half as long. In some cases the second segment is equal in length to the third.

The first segment bears an apical or subapical papilla which may exceed the second segment in length.

In the group of larvae in which the adfrontal sutures do not reach the occipital foramen there is considerable specific variation in the character of the labial palpi (fig. 9, E), while in the opposing class (fig. 9, F) there is great uniformity in the character of this part; so much, in fact, that the individual variation which occurs in any one of these species would probably nearly include the extremes shown for all the species.

SPINNERET

The spinneret (fig. 10) is a chitinized, thin, more or less transparent, dorsally concave part having its origin between and somewhat posterior to the bases of the labial palpi (fig. 8, C). It tapers somewhat toward the apex and often bears a dorsal, transverse row of setiform processes before the middle. In length, and particularly in shape, the part is subject to considerable individual variation in some species but its general character is constant.

This is another part in which a strong generic homogeneity is preserved and, for this reason, the spinneret is of little service in distinguishing closely related species of larvae. But for striking differences in form among less closely related larvae no other part equals the spinneret.

The taxonomic characters lie in the relative lengths of the spinneret and the basal joint of the labial palpi and in the character of the tip. Upon the latter character the larvae may be divided into the following classes:

Spinneret apically notched: *Agrotis ypsilon*, *Euxoa messoria*, *E. tessellata*, *E. bostoniensis*, *E. auxiliaris*, *Porosagrotis vetusta*, *Feltia annexa*, *F. gladiaria*, *F. venerabilis*, *F. ducens*, *F. subgothica*, and *F. malefida*.

Spinneret apically produced and notched: *Prodenia dolichos*, *P. eridania*, and *P. ornithogalli*.

Spinneret bluntly pointed: *Parastichtis bicolorago* and *Sidemia devastator*.

Spinneret apically truncated: *Polia renigera*, *P. legitima*, and *P. meditata*.

Spinneret tip fimbriate: *Agrotis badinodis*.

Spinneret tip spinosely produced: *Agrotis c-nigrum*, *Lycophotia infecta*, and *L. saucia*.

The following species have the spinneret exceeding the basal joint of the labial palpi: *Parastichtis bicolorago*, *Polia legitima*, *P. meditata*, *P. renigera*, *Sidemia devastator*, *Lycophotia infecta*, *L. saucia*, *Prodenia dolichos*, *P. eridania*, and *P. ornithogalli*. In *infecta* and *saucia* only the apical spines exceed the basal palpal segment.

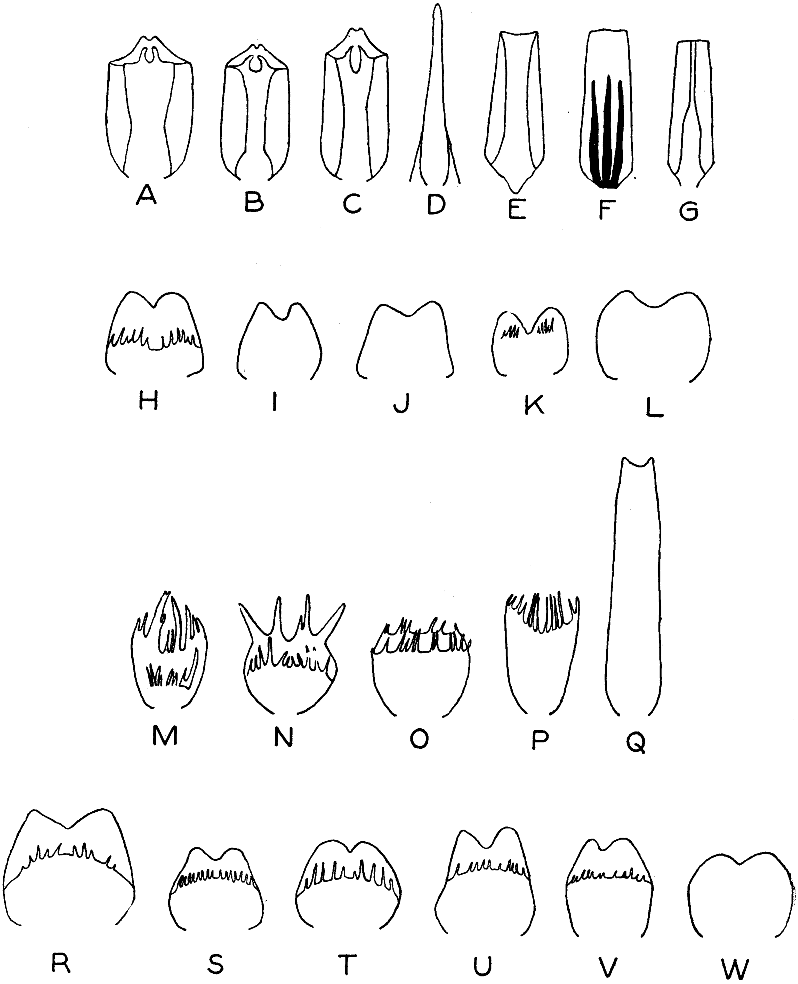


FIG. 10.—Spinnerets in several species of larvae, showing character: A, *Prodenia dolichos;* B, *Prodenia ornithogalli;* C, *Prodenia eridania;* D, *Parastichtis bicolorago;* E, *Polia legitima;* F, *P. renigera;* G, *P. meditata;* H, *Euxoa messoria;* I, *E. tessellata;* J, *E. bostoniensis;* K, *Chorizagrotis auxiliaris;* L, *Porosagrotis vetusta;* M, *Lycophotia infecta;* N, *L. saucia;* O, *Agrotis c-nigrum;* P, *A. badinodis;* Q, *Sidemia devastator;* R, *Agrotis ypsilon;* S, *Feltia ducens;* T, *F. annexa;* U, *F. malefida;* V, *F. gladiaria;* W, *F. venerabilis*

It should be clearly understood that the drawings of spinnerets represent only individual forms, and not fixed specific types, and this is especially true of the short, broad spinnerets having a median apical notch. The drawing given for any one of these latter species will probably be found to apply equally well to certain individuals of any of the other species of this class. But a species with the spinneret of the above type will never be found to vary so that this part might be confused with spinnerets such as those shown for Polia, Lycophotia, and Prodenia, and vice versa. In other words, this part is very variable in form in many cases, but these variations do not exceed the bounds of the class to which a particular form belongs.

Hypopharynx

The hypopharynx (fig. 12, B) is an oval fleshy part extending upward and backward in the floor of the mouth and merging into the labium anteriorly. It is broadest posteriorly and may be divided into three parts: (1) A raised anterior portion, the lingua, which merges posteriorly into (2) a pair of lateral lobes, the lobes of the maxillulae, and (3) a depressed area between these lobes which may be called the "gorge." The armature of spines is usually particularly heavy in an area at or near the anterior ends of the maxillulae, the premaxillulary area. The lobes of the maxillulae are usually bordered on their extero-lateral margins by a row of spinelike processes (fig. 8, B), borne on a chitinous plate, the blade of the maxillulae, which shields the maxillulae laterally and is attached to the arm of the mentum. The lingua and maxillulae are armed with spines, while the gorge is usually nearly or quite bare. These spines, which are directed backward on the median area and inward and backward on the lateral areas, may serve to force the food along into the gorge.

The hypopharynx presents a multiplicity of characters, but is disappointing when closely related species are to be differentiated, owing to the fact that great uniformity prevails with regard to the structure in these species, and the slight specific tendencies are rendered of dubious value by the rather wide variations which occur among individuals. The comparative length and breadth of the part vary decidedly in different species, as does also the proportion of the length occupied by the maxillulae, and the character of the spiny armature often shows striking specific differences. The gorge is bare posteriorly in all the species except *Lycophotia infecta*, in which it is uniformly clothed with spines throughout. The blades of the maxillulae are without spinelike processes in *Sidemia devastator* and the three species of Prodenia, and these are present in all the other species. The number of spinelike processes varies from about 10 in some species to 40 or more in others, although considerable individual variation occurs. These may be flat or terete in section, contiguous or isolated in arrangement, and in outline they may vary from acutely triangular to oblong. (Fig. 11.)

Antennae

The antennae are set on long, membranous, retractile pedicels adjacent to the base of the mandibles, and consist of four segments each. The first two segments are of about equal diameter, with the second usually much the longer, while the third and fourth are of progressively very much smaller diameter and much shorter than the basal segments, the last segment being minute and apically setiform. The second and third segments bear apically certain additional appendages, as follows:

On the second segment there is a very long seta, an adjacent much smaller seta, two fleshy papillae, and one or more minute papillae.

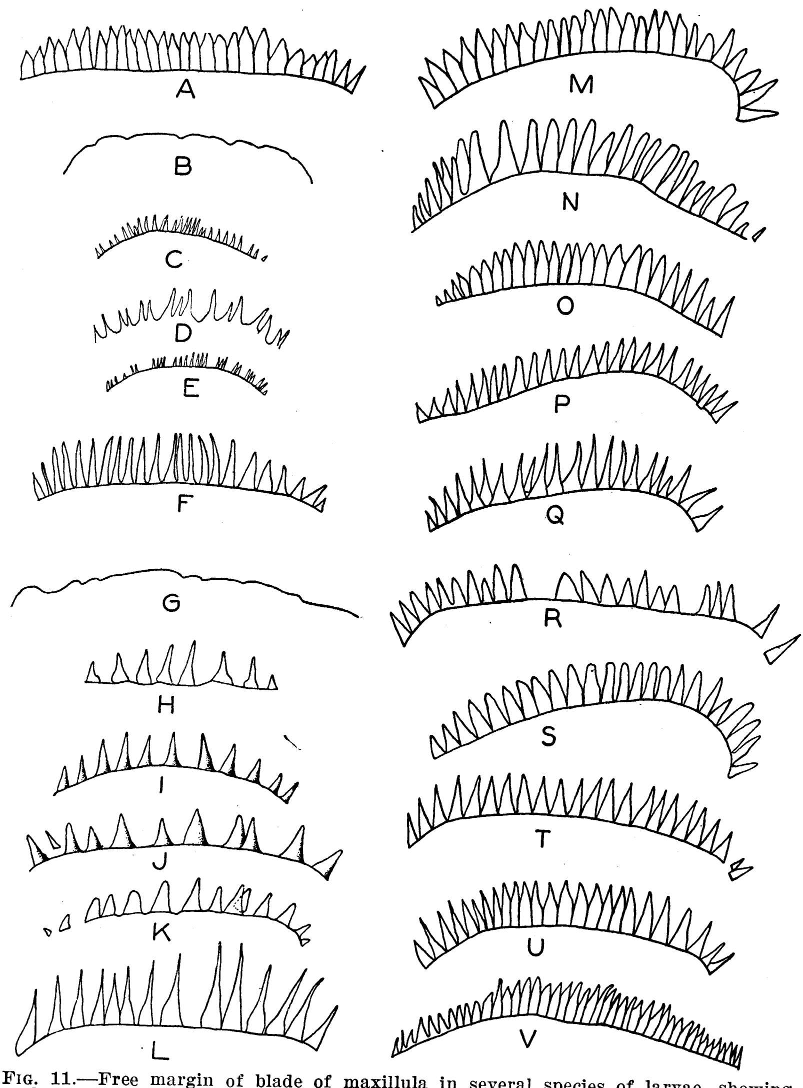


FIG. 11.—Free margin of blade of maxillula in several species of larvae, showing character: A, *Agrotis ypsilon*; B, *Prodenia* spp.; C, *Parastichtis bicolorago*; D, *Polia meditata*; E, *P. renigera*; F, *P. legitima*; G, *Sidemia devastator*; H, *Agrotis badinodis*; I, *A. c-nigrum*; J, *A. unicolor*; K, *Lycophotia infecta*; L, *L. saucia*; M, *Feltia venerabilis*; N, *F. gladiaria*; O, *F. malefida*; P, *F. annexa*; Q, *F. ducens*; R, *Porosagrotis vetusta*; S, *Chorizagrotis auxiliaris*; T, *Euxoa bostoniensis*; U, *E. tessellata*; V, *E. messoria*

The relative arrangement and form of these, as shown in Figure 12, A, is practically constant throughout the series.

The third segment bears a small more or less acutely pointed papilla and a larger papilla which may exceed the fourth segment in length.

The antennae do not offer any very available taxonomic characters. Some species have the basal joint nearly as long as the second, while in others the latter is three times as long as the former, and these undoubtedly represent specific tendencies; but there is a rather wide individual variation in the lengths of the various parts which tends to nullify the value of conclusions based upon measurements.

Agrotis badinodis and *Lycophotia saucia* have two minute pointed papillae on the apex of the third segment instead of the usual one, and *Polia meditata* has a cylindrical appendage in addition to the

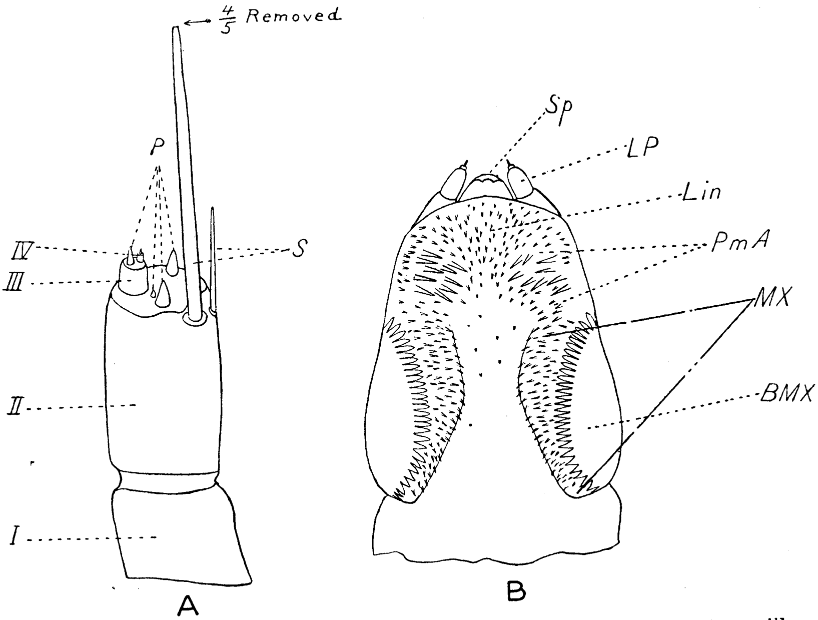


FIG. 12.—A, antenna of larva: I, II, III, IV, segments of antennae; *P*, papillae; *S*, antennal setae. B. *Agrotis ypsilon*, hypopharynx of larva; *Sp*, spinneret; *LP*, *labial palpus*, *Lin*, lingua; *PmA*, premaxillulary area; *BMx*, blade of the maxillula.

pointed papilla, while in the three species of Prodenia the papilla on the third segment is terminal and on the fourth segment subterminal.

SETIGEROUS TUBERCLES

The individual setigerous tubercles (fig. 13, A, B) are of nearly constant relative size in each species but vary in size in different species and are of fundamental importance in the classification of larvae.

In the larvae here discussed the tubercles may consist of only a minute chitinous ring encircling the base of the seta, or this ring may be surrounded by a comparatively large chitinized area which may be flat, convex, or conical.

There are no very sharply defined limits to these two classes, but the larger tubercles are confined to those species of larvae in which the adfrontal sutures attain the occipital foramen (see key to larvae, p. 26) with the exception of *Polia renigera* and *P. meditata*, and are uniformly associated with a granulose skin. The reason for these differences in the size of the tubercles is not clear to the writer. Upon the whole the group having the larger tubercles is normally more subterranean in habit than the group characterized by small tubercles, but the two species of Polia with large tubercles are no more subterranean in habit than, for example, *Agrotis c-nigrum* which has small tubercles.

There is great uniformity throughout the series in the arrangement of the tubercles as indicated for *Feltia ducens* in Figure 13, C. Even the minute subsidiary tubercles not numbered in the figure are very constant in arrangement throughout all the species here treated.

The following are among the distinctive features of the setal arrangement: Prespiracular shield of prothorax with but two setae

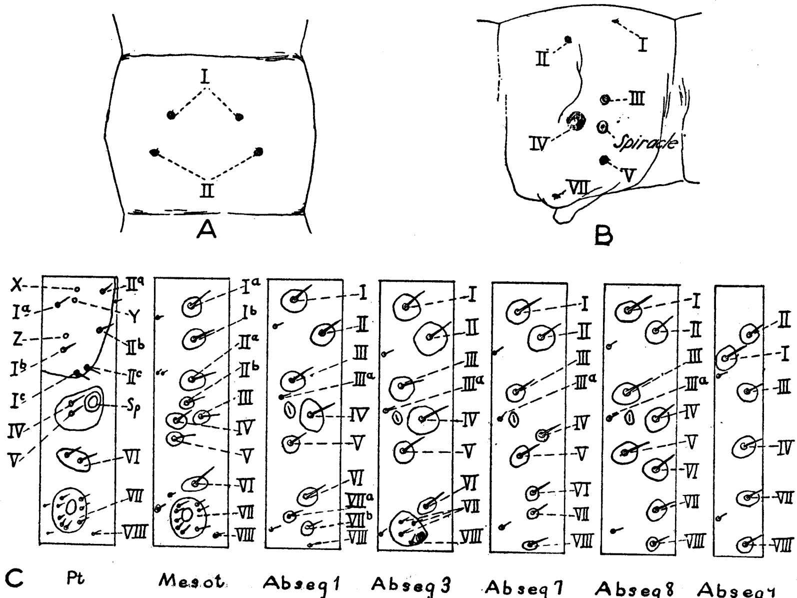


FIG. 13.—A, an abdominal segment of a larva, dorsal view, showing setigerous tubercles I (anterior) and II; B, an abdominal segment of a larva, lateral view, giving the notation of the setigerous tubercles, IV posterior to the spiracle. C, setal map of larva of *Feltia ducens*, showing arrangement of setae and punctures on the body: *Pt*, prothorax; *Mesot*, mesothorax: *Abseg 1*, first abdominal segment; *Abseg 3*, third abdominal segment; *Abseg 7*, seventh abdominal segment; *Abseg 8*, eighth abdominal segment; *Abseg 9*, ninth abdominal segment; *Sp*, spiracle

(III absent), II^a above the level of I^a and I^c and II^c approximate on prothorax, VI bisetose on prothorax and unisetose on mesothorax and metathorax, VII of abdomen trisetose on proleg-bearing segments and the second abdominal segment, VII^c absent on first abdominal segment, IV and V well separated, IV directly posterior to the spiracle on proleg-bearing abdominal segments and slightly lower and nearer to V on abdominal segment 7, six setae on ninth abdominal segment, V and VI absent, with I anterior to and nearly equidistant from II and III.

BODY SETAE

In the later instars the body setae offer no characters useful in determining the species of larvae. They are all pale brown or infuscated brown and there is no important variation in form. In the first instar, however, the setae show several decided variations, as indicated in the key to first-instar larvae. The setae may be extremely short with capitate, clavate, or pointed tips, or they may be very long with capitate or pointed tips. (Fig. 15, A–C.)

CERVICAL SHIELD

Two types of coloration of the cervical shield are found, one of which is indicated in Figure 14, A, in which the part is infuscated brown with a definite pattern of small fuscous flecks, while the other is represented in Figure 14, B. The arrangement of the setae shown in the above figures is practically constant and does not offer satisfactory taxonomic characters, but this is not quite so strictly true of the three punctures shown in the figures.

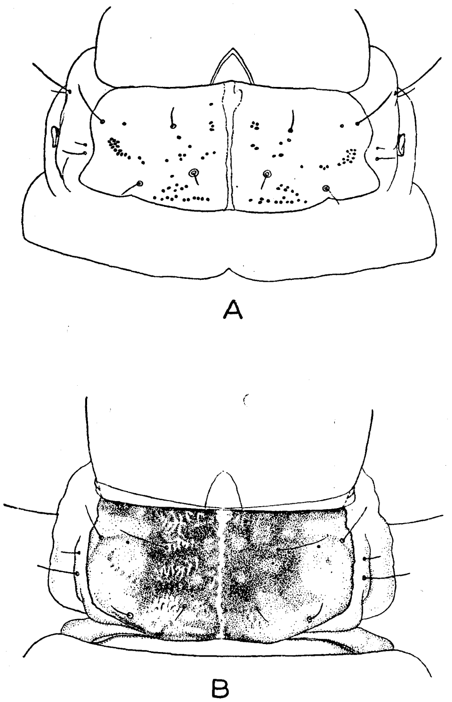


FIG. 14.—A, cervical shield of larva of *Euxoa messoria;* B, cervical shield of *Agrotis ypsilon*

These punctures (fig. 13, C) show more or less individual variation in their arrangement, but there is a close general agreement in this respect in all but a few species. In general punctures X and Y and seta I^a form an obtuse angle at Y, but in *Polia renigera* and *P. meditata* they form a right angle, and in *Sidemia devastator* puncture X is nearly on the line connecting puncture Y with tubercle II^a. Puncture Y is usually nearer to X than to tubercle I^a, but the reverse is usually true in the above species of Polia and in the species of Prodenia. In Prodenia there also seems to be present occasionally an additional puncture posterior to Y, so placed that Y is about equidistant from this and tubercle I^a. Puncture Z shows but slight variation in position throughout the series of species.

ANAL SHIELD

The anal shield bears on the apical half two transverse rows of setae, four to each row, the posterior row submarginal and shorter than the other. In first-instar larvae the shape of the shield varies in some species, as indicated in the key to larvae of this instar, but no distinctive structural characters have been observed in later stages.

LEGS

The legs offer no very important taxonomic features. The penultimate segment bears on its inner face a swelling or callus flanked on each side by a seta, one of a series of six encircling the segment. The posterior one of these two setae (the anterior one being less readily observed) varies in position with regard to its outer neighbor, which is usually set obliquely below but sometimes nearly level with the callus seta, and in *Polia legitima* is placed nearly directly beneath it. The apical segment is polished and chitinized except on its inner face and tapers somewhat toward the apex, which bears a bluntly pointed, curved claw, having a rounded or angular basal enlargement which is nearly constant in form for each species. The setae on the apical segment are not distinctive in the later instars, but in the first instar they vary considerably in form in the different species as indicated in Figure 15, A–D.

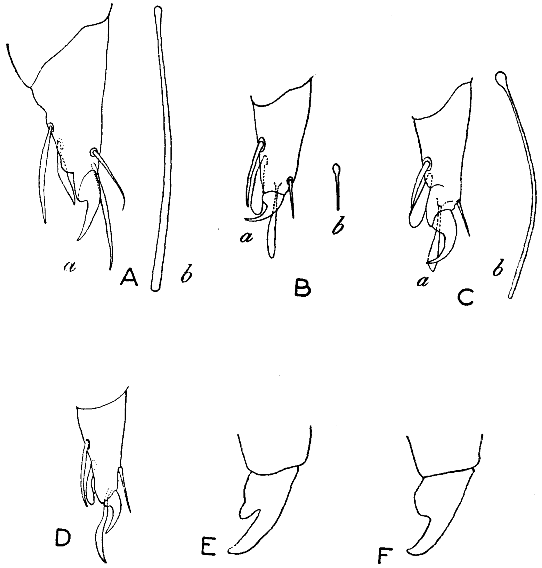


FIG. 15.—A, *Agrotis c-nigrum*, first-instar larva: *a*, tarsus; *b*, dorsal seta. B, *A. ypsilon*, first-instar larva: *a*, inner face of tarsus; *b*, dorsal seta. C, *Feltia annexa*, first-instar larva: *a*, inner face of tarsus; *b*, dorsal seta. D, *Prodenia ornithogalli*, inner face of tarsus of first-instar larva. E, claws on legs of larva of *Euxoa messoria*. F, claws on legs of larva of *Porosagrotis vetusta*

PROLEGS

The prolegs vary in shape in different species, and the shield is much more developed in some than in others. Three setae are borne on the shield and one on the inner side of the proleg. On the anal prolegs there are seven setae. These vary slightly in relative position on different segments of the same larva, but their arrangement is practically constant throughout the series. Apically the proleg bears a simple series of crochets or hooks, all of practically equal length. In the instar at which the full complement of prolegs becomes armed with crochets there are specific differences and likewise there are group differences in the manner in which the crochets are arranged when they are fully extended. All those species in which adfrontal sutures do not attain the occipital foramen (see key to larvae) spread the hooks fanlike, while those in the opposite category have the hooks arranged in a semicircle when fully extended. Also the larvae in the first of the above classes have the hooks sheathed nearly to their tips, while those in the latter group have them free. The number of crochets on each proleg increases progressively posteriorly, except in *Sidemia devastator*, and is variable only within rather narrow limits. For this reason their number on the anterior pair of prolegs has been found useful in separating some species of larvae.

SPIRACLES

No structural variations useful in distinguishing species have been observed in the spiracles. The inner portion is often of a different color from the rim; the color of both is quite constant in live larvae and, for this reason, is often useful in distinguishing species.

OUTLINE FOR DESCRIPTION OF A CUTWORM

Head shield: Width.
Body: Length, width, shape, character of skin, coloration.
Head: Ground color of shield, color and character of markings, point of termination of adfrontal sutures, character of mandible, spinneret, labial palpi, and teeth on the blade of the maxillulae, arrangement of setae and punctures.
Cervical shield: Coloration.
Anal shield: Coloration.
Setigerous tubercles: Color, relative size.
Spiracles: Color of central portion and of rim.
Legs: Color, claw with or without a basal tooth or angulation.
Prolegs: Color, number of crochets on each of the anterior pair.

KEY TO THE CUTWORMS WHICH ATTACK TOBACCO

1. Adfrontal sutures not reaching the occipital foramen (fig. 4, E). Adfrontal setae 2 set distinctly more than their width apart from the apex of the occipital foramen, usually twice or more distant. (*Lycophotia saucia* is the only species which might be considered doubtful.) Spinneret not as in the opposing category (fig. 10, A–Q). Skin smooth except in *Polia renigera* and *P. meditata*. Seta A^2 of head shield distinctly nearer to A^1 than to A^3 except in *P. renigera* and *L. infecta*____________________2
   Adfrontal sutures reaching the occipital foramen (fig. 4, D). Adfrontal setae 2 about their width apart or less removed from apex of occipital foramen. Spinneret broad and short with a median apical notch (fig. 10, H–W) except in *Sidemia devastator*. Skin granulose (fig. 4, G–J). Seta A^2 of head shield approximately equidistant from A^1 and A^3____13
2. Subdorsal black spots on eighth abdominal segment medially angulate on their dorsal faces and hence broadest about the middle (pl. 8, D–G). Apical segment of labial palpi as long as the basal segment (fig. 9, C). Blade of maxillulae without teeth (fig. 11, A–L)________________________3
   Subdorsal black spots on eighth abdominal segment absent or broadest posteriorly, not angulate on their dorsal faces (pl. 9, A–I). Apical segment of labial palpi not more than half as long as the basal segment (fig. 9, D). Blade of maxillulae with teeth (fig. 11)__________________5
3. Adfrontal area and sutures conspicuous white (fig. 4, C). Brown of head shield almost entirely obscured by solid black________________________4
   Adfrontal area pale brown, sutures pale but not white. Head shield a bright brown, which may be somewhat infuscated in an area beside the front____________________________*Prodenia eridania* Cramer (pl. 8, G, L).
4. Subdorsal black spots on mesothorax absent or distinctly much smaller than those on eighth abdominal segment. Coloration made up of strands. *Prodenia ornithogalli* Guenée (pl. 8, D, K).
   Subdorsal black spots on mesothorax nearly or quite as large as those on eighth abdominal segment. Coloration made up of dots. *Prodenia dolichos* Fabricius (pl. 8, F).
5. Mandibles each with about five teeth. Epipharyngeal setae short and stout____6
   Mandibles with cutting margin straight and toothless or bearing about 12 minute teeth (fig. 6, A). Epipharyngeal setae long and bristlelike. *Lycophotia infecta* Ochsenheimer (pl. 7, G, L, M).
6. Without a segmental series of markings in the dorsal area and not prominently striped. Spinneret not more than twice as long as broad, the tip fimbriate or spinosely produced (fig. 10, M–P)________________________7
   With a segmental series of infuscated markings in the dorsal area, at least posteriorly, or else prominently striped. Spinneret at least three times as long as broad, the tip simple (fig. 10, D–G)________________________10

7. Black subdorsal markings linear or absent. Mandibles without an internal tooth. Adfrontal setae 2 set distinctly less than twice their width apart from the apex of the occipital foramen. With a distinct mid-dorsal yellow dot on each abdominal segment, at least anteriorly. *Lycophotia saucia* Hübner (pl. 7, H, N).
With triangular black subdorsal markings at least posteriorly. Mandibles each with a large internal tooth about midway of the first ventral rib (fig. 6, D–F). Adfrontal setae 2 set distinctly more than twice their width apart from apex of occipital foramen 8
8. Spiracles yellowish or white with black rims 9
Spiracles black. With large black spots above the spiracles. Ground color of head shield pale yellowish brown. Internal tooth of mandible bidentate (fig. 6, F) *Agrotis badinodis* Grote (pl. 9, D, E, H).
9. Without black spots above the spiracles. Internal tooth of mandible triangular (fig. 6, E). Ground color of head shield grayish or whitish. Black subdorsal spots not including setigerous tubercle I except on some posterior segments *Agrotis c-nigrum* Linnaeus (pl. 9, A, C, G).
Usually with black spots above the spiracles. Internal tooth of mandibles with a broad apex (fig. 6, D). Ground color of head shield pale brown. Black subdorsal spots with an angular extension, including setigerous tubercle I *Agrotis unicolor* Walker (pl. 9, F, I).
10. Dorsal area occupied by a series of infuscated markings on a paler ground. Mandibles of ordinary type (fig. 6, C) 11
Dorsal area occupied by a solid black stripe. Mandibles with a complicated inner structure (fig. 6, B) *Polia legitima* Grote (pl. 8, C, J).
11. Markings in dorsal area shield-shaped. Skin smooth. Width gradually increasing from the head to the eighth abdominal segment. Tubercles minute *Parasitichtis bocolorago* Guenée (pl. 7, E, F).
Markings in the dorsal area rhomboidal or ovoid. Skin granulose. Abdominal segments of about equal width throughout. At least some of the setigerous tubercles large 12
12. Setigerous tubercles flat, IV conspicuously larger than I or II. Skin finely pavement-granulose. Head shield smooth, shiny. Setae minute, slender *Polia meditata* Grote (pl. 8, B, I).
Setigerous tubercles conical, IV scarcely larger than I and II. Skin with coarse, isolated granules (fig. 4, I). Head shield coarsely granulose. Setae stout *Polia renigera* Stephens (pl. 8, A, H).
13. Coloration like that of a white grub. Skin granules obscure. Ocellar seta 2 set distinctly more than the width of the ocellus from the ocellus. The three setae on first joint of maxillary palpi broad and spatulate (fig. 9, A) *Sidemia devastator* Brace.
Coloration normal. Skin granules distinct. Ocellar seta 2 set less than the width of the ocellus from the ocellus. The three setae on the first joint of the maxillary palpi in the form of coarse setae (fig. 9, B) 14
14. Skin granules very small, flat or slightly convex, and set pavementlike without secondary granules (fig. 4, J) 15
Skin granules coarse, isolated, strongly convex or bluntly conical and interspersed irregularly with small secondary granules (fig. 4, F–I) 22
15. Reticulation of head shield replaced entirely by close-set fuscous or brown flecks (fig. 4, A). Cervical shield infuscated brown with a definite pattern of small fuscous spots as shown in Figure 14, A. With a distinct subspiracular white band (except in *Euxoa bostoniensis*) The Euxoa group.
Head shield more or less fuscous- or ferruginous-reticulate (fig. 4, B). Coloration of cervical shield as shown in Figure 14, B. White subspiracular band not distinct The Feltia group. 20.
16. Process at base of claw broadly rounded, not at all angulate (fig. 15, F). Puncture A^a of head shield decidedly nearer to seta A^2 than to puncture P^a. Setae P^2, P^1 and Adf^1 not in a straight line. Punctures P^a and A^a not in a straight line with seta A^3. Dorsum light gray. *Porosagrotis vetusta* Walker.
Process at base of claw acutely angulate (fig. 15, E). Puncture A^a nearly or quite equidistant from seta A^2 and puncture P^a. Setae P^2, P^1, and Adf^1 approximately in a straight line. Punctures P^a and A^a approximately in a straight line with seta A^3 17

17. Pigment flecks on head shield very pale fuscous or brownish (fig. 16, A). Tubercle II, on abdomen, about three times as large as tubercle I. Dorsum tinged with brownish____*Chorizagrotis auxiliaris* Grote (pl. 7, A, I).
Pigment flecks on head shield dark fuscous. Tubercle II, on abdomen, about twice as large as tubercle I____18

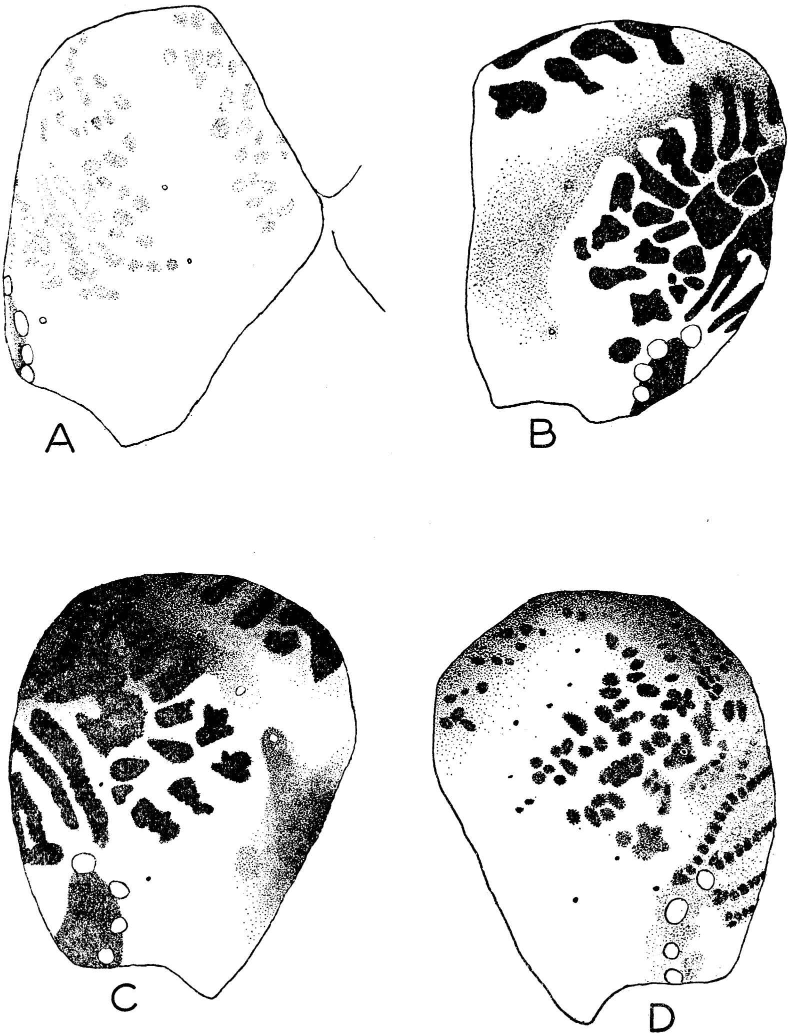


FIG. 16.—Coloration of head shield of larva: A, *Chorizagrotis auxiliaris*, right half; B, *Euxoa bostoniensis*, left half; C, *E. tessellata*, right half; D, *E. messoria*, left half

18. With no trace of a white band or white splotches subspiracularly. Entire body a nearly uniform drab above the spiracles. Flecks of head shield deep fuscous, nearly black, and of the character shown in Figure 16, B. *Euxoa bostoniensis* Grote.
With a distinct white band or distinct white splotches subspiracularly. Dorsum tinged with dull ferruginous________________________________19

19. Head shield but slightly infuscated dorso-laterally. Markings centering upon the ocelli composed of distinctly separate spots (fig. 16, D).
Euxoa messoria Harris (pl. 6, B, J).
Head shield heavily infuscated dorso-laterally. Markings centering upon the ocelli stripelike (fig. 16, C)..................*Euxoa tessellata* Harris.
20. Tubercle I of abdominal segments nearly or quite as large as tubercle II. Spiracles set in the pale ventral coloration. Anterior prolegs of mature larva with about 12 crochets each..*Feltia malefida* Guenée, pl. 6, F, G, L).
Tubercle I of abdominal segments about one-half as large as tubercle II. Spiracles set in the dark supraspiracular coloration. Anterior prolegs of mature larva with about six crochets each..........................21
21. Dorsum uniform dark gray concolorous with the supraspiracular area. Basal portion of claw distinctly, acutely angulate. Head shield of mature larva 3.5 mm. broad..............*Feltia venerabilis* Walker (pl. 6, D, J).
Dorsum distinctly paler than the supraspiracular area and tinged with ferruginous. Basal portion of claw broadly rounded, but slightly angulate. Head shield of mature larva 3.2 mm. broad.
Feltia gladiaria Morrison (pl. 6, C, I).
22. Skin granules upright, conical, somewhat retrorse (fig. 4, C). Tubercle I of abdominal segments about one-half as large as tubercle II.
Feltia annexa Treitschke (pl. 6, E, K).
Skin granules strongly convex but scarcely subconical, not at all retrorse (fig. 4, F–H)..23
23. Tubercle I of abdominal segments nearly or quite as large as tubercle II. Fuscous coloration of supraspiracular area strongly intensified subdorsally on anterior half of each abdominal segment.
Feltia ducens Walker (pl. 6, A, H), *Feltia subgothica* Haworth (pl. 5, B).
Tubercle I of abdominal segments about one-third as large as tubercle II. Fuscous coloration of supraspiracular area not intensified as above.
Agrotis ypsilon Rottemburg (pl. 7, C, K).

EGGS AND FIRST-INSTAR LARVAE

In the case of species having a remarkably long egg stage the eggshell in reality constitutes a sort of cocoon for the larva, which lies within, fully developed but quiescent, after about the first two weeks. Such eggs constitute a portion or the whole of the overwintering stage of the insect in such cases, and it is probable that the unorganized egg is less resistant to cold than is the fully developed larva. This is certainly the case with some species having a short egg stage. After the larva has fully developed these eggs acquire a dull plumbeous tone which renders them very inconspicuous.

In all species in which the egg stage may be long the setae of the first-instar larvae are very short. The greater part of a very prolonged egg stage is spent as a quiescent larva, and it may be that the short setae in these species are an adaptation to life during this extended period in the cramped quarters afforded by the eggshell. *Agrotis ypsilon* is the only known species having a short egg stage in which the first-instar larvae have very short setae.

It is probable that in all species in which the eggs are deposited in a mass the larvae are normally distributed to some extent by being floated away on the wind. This means of dispersion has been observed in *Lycophotia saucia*, *L. infecta*, *Polia legitima*, and *Prodenia ornithogalli*. In these species the setae are only slightly capitate and they are no longer than in many species in which wind dispersion apparently does not occur. The eggs in the better-known species having this habit are usually deposited upon elevated objects. Very likely the different species do not utilize this means of dispersion to the same degree. The occurrence of larvae of *Prodenia ornithogalli*, for example, would suggest that this was the normal habit of the species, while *L. saucia* is frequently locally abundant and would seem to utilize wind dispersion only to a minor degree.

In the preceding key to the more mature larvae two major groups were indicated, based on whether or not the adfrontal sutures terminate in the occipital foramen. These sutures are not clearly defined in first-instar larvae, but the two groups are still separable, nearly intact, on other characters. The species in which the adfrontal sutures of the more mature larvae terminate in the occipital foramen have the prolegs absent on the third abdominal segment in the first instar, while in the opposite category the prolegs are present on the third abdominal segment in all but *Polia renigera* and *P. meditata*. Prolegs on the third abdominal segment are invariably associated with a U-shaped anal shield, while the anal shield is entire posteriorly in species lacking prolegs on this segment.

Fertile eggs develop color some days after deposition, which may consist entirely of a belt and micropylar splotch of pink, reddish brown, or chocolate brown, or may be diffused over nearly the entire egg with or without some indication of the belt and splotch. There seems to be a tendency for eggs deposited later in the season to have the color diffused.

First-instar larvae will rarely be obtained where they can not be associated with the eggs, and determinations of either the eggs or the larvae by means of the following keys will be more satisfactory where they may be checked or made more definite by a determination of the other stage.

KEY TO EGGS OF CUTWORM-PRODUCING SPECIES

1. Eggs deposited in a mass (pl. 5, A, B.) ---- 2
   Eggs deposited singly or only a few together ---- 3
2. Egg mass bare. Egg 0.55 mm. wide and 0.40 to 0.45 mm. high, with about 35 ribs ---- *Lycophotia infecta, L. saucia, Polia legitima.*
   Egg mass covered and intermingled with scales from the moth. Egg 0.45 mm. wide and 0.35 mm. high, with about 50 ribs. *Prodenia dolichos, P. eridania, P. ornithogalli.*
3. Eggs oblong-oval in outline ---- *Feltia ducens, F. subgothica.*
   Eggs round in outline ---- 4
4. Ribs replaced by coarse hexagonal reticulation excepting near apex. Egg distinctly higher than broad ---- *Polia meditata.*
   Ribs present. Egg broader than high ---- 5
5. Egg 0.75 mm. broad and 0.65 mm. high ---- 6
   Egg not over 0.70 mm. broad and 0.55 mm. high ---- 7
6. With about 65 ribs composed of overlapping scalelike granules. *Feltia gladiaria.*
   With about 42 solid, normal ribs ---- *Feltia venerabilis.*
7. With about 25 ribs or less ---- 8
   With about 35 ribs or more ---- 11
8. Ribs thin, laminate ---- *Agrotis badinodis.*
   Ribs of a different character ---- 9
9. Ribs very slender, scarcely heavier than the transverse lines. *Euxoa agrestis.*
   Ribs strong, much heavier than the transverse lines ---- 10
10. Egg 0.55 mm. broad and 0.31 mm. high, uniform pale chocolate brown. *Parastichtis bicolorago.*
    Egg 0.70 mm. broad and 0.55 mm. high, with a distinct belt and micropylar splotch of reddish brown ---- *Polia renigera.*
11. With distinct belt and micropylar splotch of pinkish. *Feltia annexa, Agrotis ypsilon.*
    Without a belt and splotch of color, color diffused over the entire egg or absent ---- *Feltia malefida, Euxoa messoria, Agrotis c-nigrum.*

KEY FOR THE DETERMINATION OF FIRST-INSTAR LARVAE

1. Prolegs present on third abdominal segment. Anal shield U-shaped; deeply emarginate or incised posteriorly ---- 2
   Prolegs absent on third abdominal segment. Anal shield entire posteriorly ---- 4
2. Dorsal setae capitate, at least nearly equalling an abdominal segment in length ---- 3
   Dorsal setae pointed, about one-fifth the length of an abdominal segment. *Parastichtis bicolorago.*
3. Setigerous tubercle I of abdomen distinctly larger than II ---- *Lycophotia saucia.*
   Setigerous tubercle I of abdomen of about the same size as II. *Lycophotia infecta, Agrotis c-nigrum, A. badinodis, Prodenia dolichos, P. ornithogalli, Polia legitima.*
4. Head black or dark fuscous ---- 5
   Head brown or pale fuscous brown ---- *Polia renigera, P. meditata.*
5. Dorsal setae at least two-thirds the length of an abdominal segment. *Feltia ducens, F. subgothica, F. annexa, F. malefida*
   Dorsal setae not over one-third the length of an abdominal segment ---- 6
6. Setae clavate ---- *Agrotis ypsilon.*
   Setae capitate ---- 7
7. Larva with anal shield entire anteriorly ---- *Feltia gladiaria.*
   Larva with anal shield emarginate anteriorly, at least in *messoria.* *Euxoa messoria, E. auxiliaris.*

PUPAE OF TOBACCO CUTWORMS

In these pupae the number of characters available for distinguishing the species is limited. The arrangement of the appendages is practically identical throughout the series, except that in *Sidemia devastator* the tips of the metathoracic legs are not visible on the median line posterior to the tips of the wings while they are visible in all the other species. The maxillary palpus is usually visible as a small triangle at the outer angle of the eye in *Euxoa auxiliaris*, *E. tessellata*, *E. messoria*, *E. bostoniensis*, *Porosagrotis vetusta*, *Feltia annexa*, *F. malefida*, *Agrotis ypsilon*, *A. c-nigrum*, *A. unicolor*, *Sidemia devastator*, *Lycophotia saucia*, and *L. infecta*.

The clypeus is always demarked from the head by a groove and the labrum may be emarginate or not, the species seeming to be fairly constant with regard to this character. All of the species in which the adfrontal sutures of the larva terminate in the occipital sinus (see Key to larvae), with the exception of *Agrotis ypsilon*, have a distinct callus on the prothorax immediately anterior to the mesothoracic spiracle. This callus is absent in the opposite category. The anterior dorsal margins of the movably-linked abdominal segments have a row of round pits in *Agrotis badinodis*, elongate punctures in *Feltia annexa* and *Agrotis ypsilon*, and round punctures in all the other species. In the species of Prodenia the spiracles are set on the posterior face of a callus and have a decided posterior direction, while all the other species have the spiracles directed laterally or very slightly posteriorly.

The cremaster is very useful in distinguishing the species, although it may be somewhat variable and often becomes distorted or broken, particularly in reared material. There are usually two main apical spines (four being present, however, in *Sidemia devastator*) formed apparently by the fusion of the four apical setae on the anal shield of the larva, and in some species four much smaller accessory setae are present anterior to the main spines and apparently representing the anterior row of setae on the anal shield of the larva. The main spines may be directed downward or horizontally, and may be parallel, divergent, or convergent, and in nearly every case each spine has an enlarged basal portion.

There is usually a definite striate or rugulose area both anterior to and below the main spines of the cremaster. These areas are smooth in *Euxoa auxiliaris*, *E. messoria*, *Agrotis c-nigrum*, *Lycophotia saucia*, and *L. infecta;* are minutely roughened in *Feltia ducens*, *F. subgothica*, and the species of Prodenia; and are very conspicuously rugulose in *Polia renigera* and *P. meditata*.

The contour of the body probably affords some characters for distinguishing species of pupae, but the material at hand, consisting entirely of pupal cases from which the moths have emerged, does not furnish satisfactory evidence with regard to this feature. In most species the pupal wall is thin and fragile and the movably linked abdominal segments telescope into one another when the moth emerges, but in the species of Polia, Agrotis of the *c-nigrum* group, and Prodenia the pupal case is more heavily chitinized and the abdomen retains its shape after the emergence of the moth. Pupae of the latter type are particularly resistant to desiccation, and the increased chitinization of the body wall may be an adaptation to this end.

The determination of pupae may often be rendered much more satisfactory if the larval skin cast at pupation is at hand. This skin not infrequently possesses discernible characters such that by consulting the key to the mature larvae the pupal determination may be checked up. Thus the skin will show whether the larva belonged to the class with smooth skins or to the one with granulose skins; the head shield of Euxoa and its allies will still show the characteristic fuscous or brown flecks and the pattern and intensity of coloration of these markings will furnish additional evidence as to the species under observation; also the mandibles of the species of Agrotis will furnish evidence; and the character of the skin and size of tubercles I and II will be sufficient for the positive determination of *Agrotis ypsilon*, *Feltia annexa*, and *F. ducens-subgothica*. The cast larval skin can be more satisfactorily studied after it has been boiled for a time.

Owing to the small number of features upon which characterizations must be based and to the variation which occurs in most of these the best that may be hoped for in a key is a guide to the identification of average specimens. Unfortunately the writer's material has not been sufficient in several cases to determine definitely what this average condition is. The key which follows is presented in this faulty condition in the hope that it may nevertheless prove somewhat helpful.

KEY TO THE PUPAE OF TOBACCO CUTWORMS

1. With a distinct callus on prothorax before mesothoracic spiracle---------2
   Without a callus on prothorax before mesothoracic spiracle-------------10
2. Maxillary palpus visible as a minute triangle at outer angle of eye-------3
   Maxillary palpus not visible. Spines of cremaster set on a distinct process--9
3. Cremaster with accessory setae--4
   Cremaster without accessory setae. Dorsal abdominal punctures round---6
4. Main spines of cremaster with their outer margins parallel, the inner margins divergent from the base. Dorsal abdominal punctures elongate oval--*Feltia annexa* (fig. 19, F).
   Dorsal abdominal punctures round--------------------------------------5

5. Main spines of cremaster set on the tip of the abdomen without a basal process. Accessory setae distinct ------------ *Euxoa messoria* (fig. 19, E).
   Main spines of cremaster set on a distinct process. Accessory setae minute ------------ *Euxoa tessellata.*
6. Spines of cremaster set on a distinct process ------------ 7
   Spines of cremaster set on tip of abdomen without a distinct basal process -- 8
7. No distinct margin to cremaster laterad of the base of the spines. Labrum apically emarginate ------------ *Porosagrotis vetusta.*
   Cremaster extending as a thin margin laterad of the base of the spines. Labrum not apically emarginate ------------ *Euxoa bostoniensis.*
8. Cremaster smooth both above and below the spines, enlarged basal portion of spines polished ------------ *Chorizagrotis auxiliaris.*
   An area below the spines of the cremaster finely striate, anterior to and including the bases of the spines coarsely obscurely rugulose. *Feltia malefida.*
9. Cremaster rather coarsely rugulose both below and anterior to the spines, which are divergent ------------ *Feltia venerabilis, F. gladiaria* (fig. 19, A).
   Cremaster minutely roughened in a small area anterior to and a larger one below the spines, which are long, polished, and convergent. *Feltia subgothica, F. ducens* (fig. 19, B).
10. Anterior dorsal margin of some of the abdominal segments with a transverse row of large, round pits. Cremaster a long conical process bearing apically a pair of short, stout, outcurved spines ------ *Agrotis badinodis* (fig. 17, C).
    Abdominal segments with punctures only. Cremaster not as above ------ 11
11. Spiracles set on the posterior face of a callus and directed decidedly posteriorly ------ *Prodenia ornithogalli* (fig. 19, D), *P. dolichos, P. eridania.*
    Spiracles directed laterally ------------ 12
12. Cremaster very coarsely rugulose dorsally and ventrally, spines long and stout ------------ 13
    Cremaster not as above ------------ 14
13. Spines of cremaster set on a distinct process ----- *Polia renigera* (fig. 17, E).
    Spines of cremaster set on an indefinite process -- *Polia meditata* (fig. 17, D).
14. Cremaster a strongly depressed appendage bearing apically four spines of practically equal size. Tips of metathoracic legs not visible medially posterior to the wings ------------ *Sidemia devastator.*
    Cremaster not as above. Tips of metathoracic legs visible ------------ 15
15. Entire abdomen coarsely sculptured ------------ *Polia legitima* (fig. 17, F).
    Abdomen not as above ------------ 16
16. Dorsal abdominal punctures elongate oval ------ *Agrotis ypsilon* (fig. 19, C).
    Dorsal abdominal punctures round ------------ 17
17. Cremaster with accessory spinules, main spines set on a process ---------- 18
    Cremaster without accessory spinules, main spines set on the tip of the abdomen without a basal process ------------ 19
18. Main spines of cremaster forming a lyre-shaped figure, accessory spinules apically hooked ------ *Agrotis c-nigrum* (fig. 17, A), *A unicolor* (fig. 17, B).
    Main spines of cremaster convergent, downward directed, not forming a lyre-shaped figure, accessory spinules not hooked. *Parastichtis bicolorago* (fig. 18, E).
19. Main spines of cremaster parallel on basal half. *Lycophotia saucia* (fig. 18, A, B).
    Main spines of cremaster divergent from the base. *Lycophotia infecta* (fig. 18, C, D).

BREEDING METHODS

In the following pages the methods employed in breeding cutworms are given in some detail, for the reason that this work has been successfully reduced to routine during the course of this investigation. Printed instructions can not entirely take the place of experience, however, since the species vary in their requirements.

Moths to be used for breeding may be reared or may be caught in bait traps. Ordinary flytraps baited with fermenting fruits will take many moths. Reared moths must be liberated in a cage for a period of from 3 to 10 days after emergence, in order that the eggs may be matured and fertilized. The procedure is then the same as for moths taken in traps. These are placed at once in shell vials about an inch in diameter, which are plugged with cotton and laid in a dark place. On alternate nights thereafter the moths should be liberated in a cage, say 3 feet square and 3 feet high, covered with cheesecloth, with a wire screen bottom and having a door opening

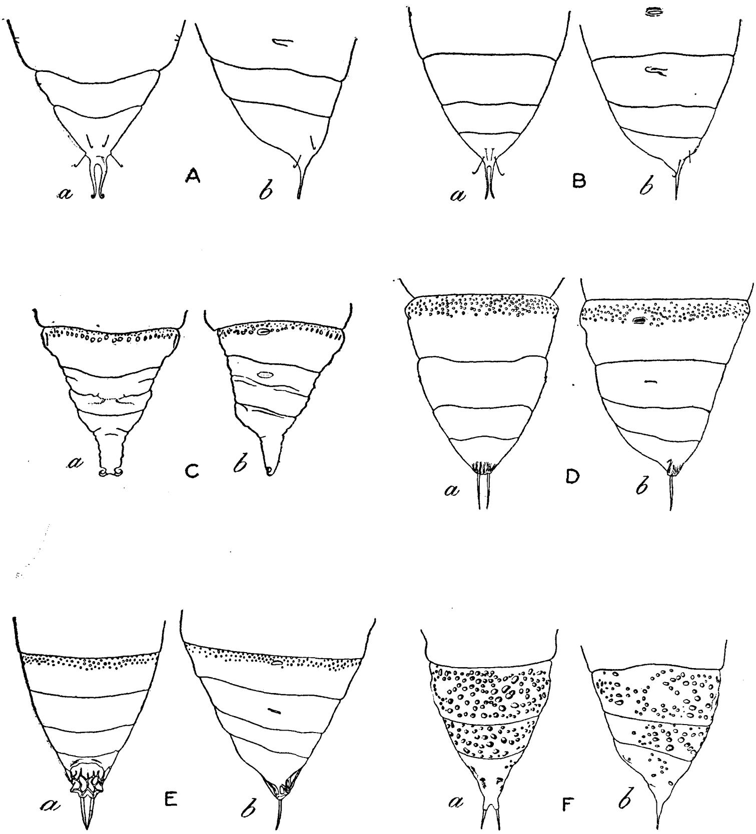


FIG. 17.—Tip of abdomen of pupa: A, *Agrotis c-nigrum: a,* dorsal view; *b,* lateral view. B, *A. unicolor: a,* dorsal view; *b,* lateral view. C, *A. badinodis: a,* dorsal view; *b,* lateral view. D, *Polia meditata: a,* dorsal view; *b,* lateral view. E, *P. renigera: a,* dorsal view; *b,* lateral view. F, *P. legitima: a,* dorsal view; *b,* lateral view

on the darker side. (Pl. 1, C.) A shell vial filled with sweetened water and stoppered with a firm plug of absorbent cotton is placed in the cage to provide food for the moths. It may be necessary to remove this occasionally when moths gorge themselves too freely.

When eggs are obtained the vials should be labeled and kept under observation, and the resulting larvae may be shaken out into an appropriately labeled glass tumbler partially filled with fresh, dry, white clover and covered with a piece of cheesecloth held in place by a rubber band. The tumbler is now inverted on a smooth surface out of direct sunlight.

As the larvae grow they should be divided out into additional tumblers from time to time until finally there is but one larva to each tumbler. After they become large enough to handle easily the larvae may be isolated singly in tin boxes, as described later. The latter method has several advantages. Neither method is uniformly successful with all species. In the case of specimens of special value, a little more assurance of successful pupation may sometimes be had if the larvae, after they have ceased feeding prior to pupation, are put in burnt clay or plaster of Paris cells sunk in moist sand, as described below. All of the writer's breeding work has been done in an open insectary. The temperature records are

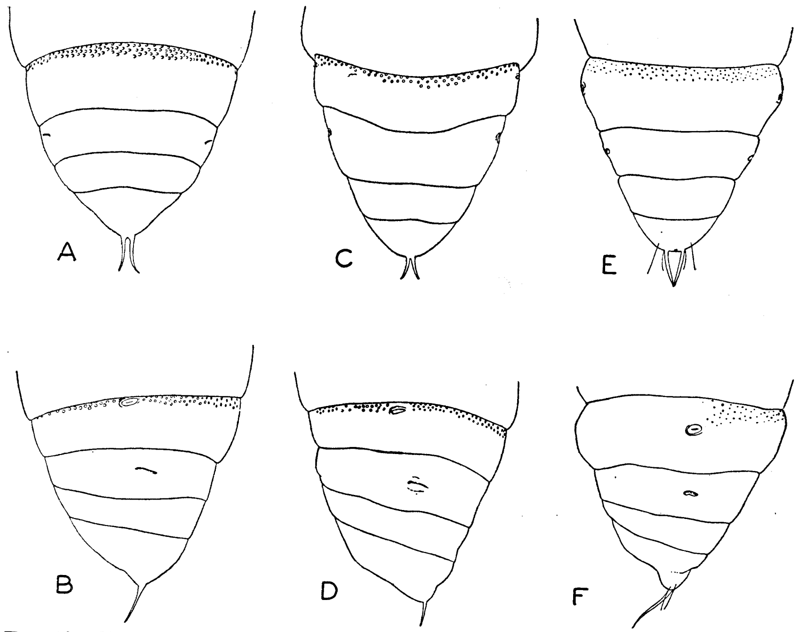


FIG. 18.—Tip of abdomen of pupa. A, *Lycophotia saucia,* dorsal view; B, same, lateral view; C, *L. infecta,* dorsal view; D, same, lateral view; E, *Parastichtis bicolorago,* dorsal view; F, same, lateral view

from the Weather Bureau instruments, which are located about a mile from the laboratory.

PROCEDURE IN REARING FIELD LARVAE

When very large numbers of larvae are received the cage shown in Plate 1, B (designed by A. C. Morgan) has been found very useful for temporary accommodation of the larvae, but mortality is very high if large numbers are confined in it for more than a few days. This cage is made of galvanized iron with the bottom and top consisting mainly of wire screen. It is about 18 inches in diameter and 6 inches deep and has a handle of strap iron. Where the material is known to consist of only one species and time does not permit more careful treatment, larvae may be carried to pupation in comparatively small numbers by placing a quantity of green food in this cage, which will then require no further attention for several days, unless larvae as they prepare for pupation are removed to more favorable quarters.

In case data on the percentage of parasitism, or the species of parasites, or an exact record of the species of larvae included in the collection are desired, the method pursued must be one affording conditions more favorable than those obtained in the large cage just described.

TIN-BOX METHOD

For all-round information the tin-box method[3] of breeding is probably the most satisfactory. Very nearly normal conditions may

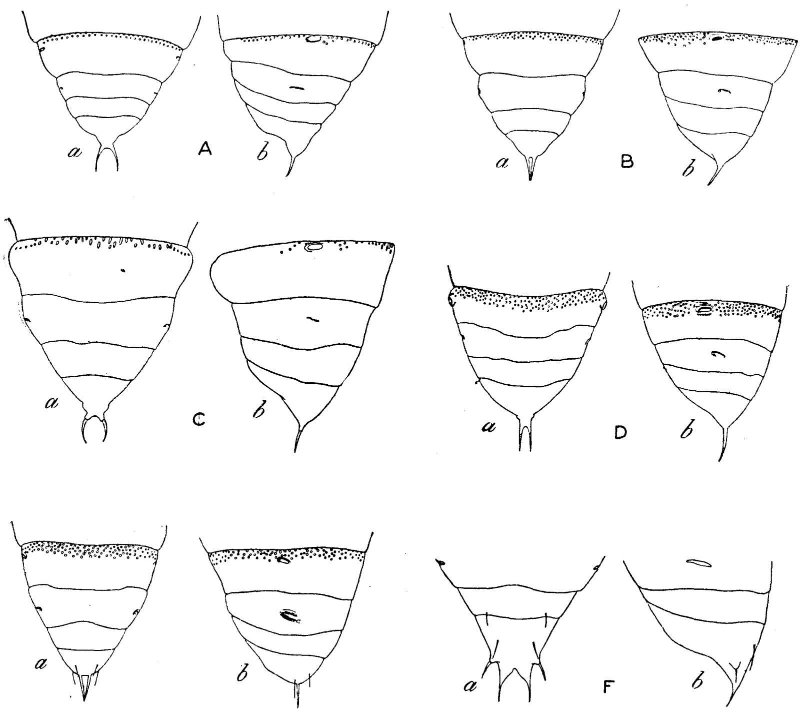
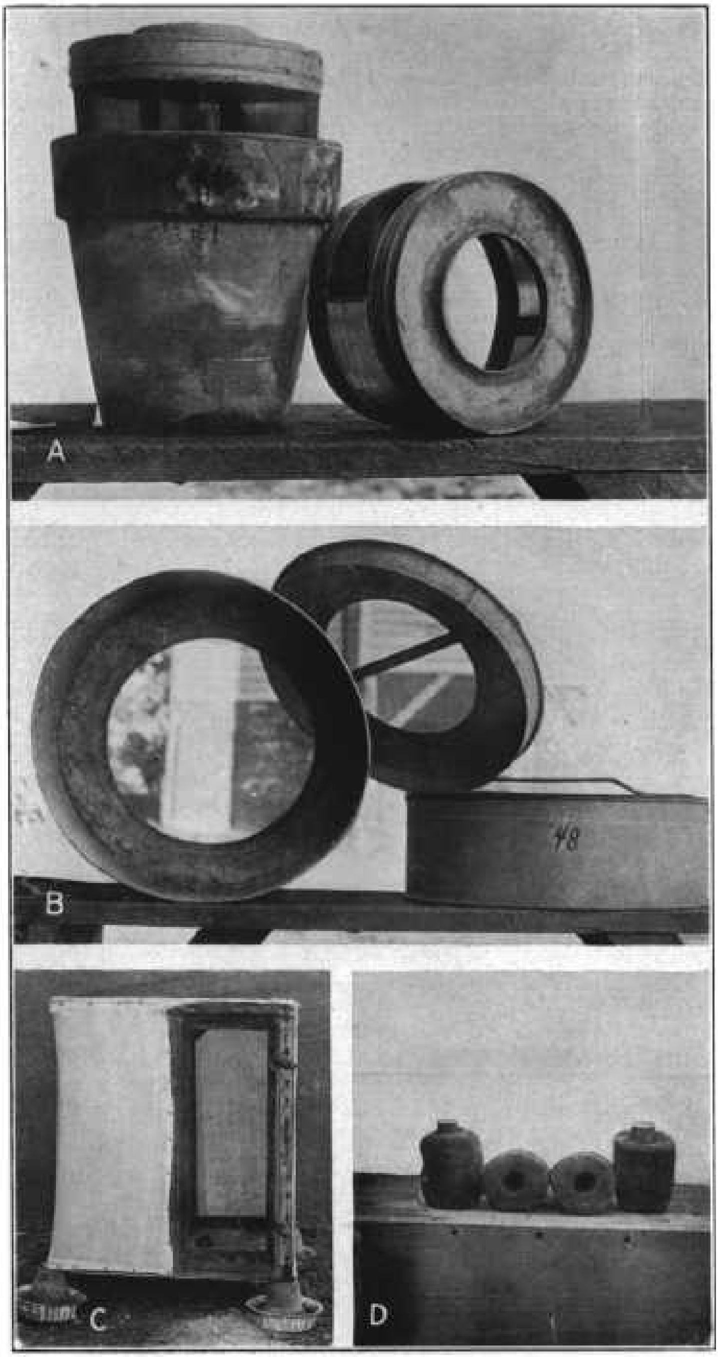


FIG. 19.—Tip of abdomen of pupa: A, *Feltia gladiaria: a,* dorsal view; *b,* lateral view. B, *F. ducens: a,* dorsal view; *b,* lateral view. C, *Agrotis ypsilon: a,* dorsal view; *b,* lateral view. D, *Prodenia ornithogalli: a,* dorsal view; *b,* lateral view. E, *Euxoa messoria: a,* dorsal view; *b,* lateral view. F, *F. annexa: a,* dorsal view; *b,* lateral view

be preserved; the material is in very compact form; and it can be examined rapidly and satisfactorily. The deep form of 2-ounce seamless tin salve boxes is about right for cutworm breeding. These are about half filled with sifted loamy earth, and a number of the boxes may then be placed on a support in a vessel (a large, clean lard can being satisfactory) having a tight lid and containing some water. By applying heat to this vessel the boxes and contents may be sterilized by steam so that most of the spores of molds may be destroyed. This is essential in most cases for success in the use of

[3] The writer obtained his introduction to the tin-box method of breeding through the kindness of J. J. Davis (*21*).

36a



CAGES USED IN BREEDING CUTWORMS

A, Pot cage with ventilator; B, large breeding cage; C, oviposition cage; D, clay cells boxes, which should be subjected to the steam for an hour or more, or better, they should receive two sterilizations some days apart. After the boxes become sufficiently cool and dry, the larvae and food may be entered. The food should be renewed frequently, as it soon becomes unsatisfactory in the closed box, and all old food should be removed as soon as the larvae cease feeding preparatory to pupation. The necessary moisture may be maintained by adding a few drops of water to the soil, as needed, by means of a pipette. The necessary data may be written directly on the tin box with a wax pencil such as is used for marking chinaware, or it may be found more satisfactory to merely number the boxes and keep a separate record. The boxes may be kept in shallow trays for ease in handling, and these trays may be slid into a frame after the manner of a series of drawers.

USE OF BAKED-CLAY CELLS

For certain larvae, especially for those having a prolonged aestivating stage, clay cells have been found very useful. They are molded to the proper form (pl. 1, D) and then placed in a pile of wood, which is then fired. They may be sterilized by boiling. When in use they are sunk nearly to the top in a mass of sand which is occasionally moistened, the larvae being confined in the cell by means of a compact plug of absorbent cotton. After pupation the cotton is removed and a lantern globe or other cage placed over the cell to secure the moth. Cells made of plaster of Paris would probably be satisfactory, but these have not been tested thoroughly.

POT CAGE WITH VENTILATOR

A considerable number of larvae may be entered in a pot cage with ventilator (pl. 1, A), which also permits the inclusion of a mass of food sufficient to satisfy the larvae for several days. The pot should be of such a size that the ventilator fits tightly and should be rather firmly packed to within 2 or 3 inches of the top with earth, which should be kept slightly moist. The ventilator (designed by Henry Fox and A. C. Morgan) is the main feature of this cage. It is made of galvanized iron and (in this cage) very fine mesh wire cloth. The opening in the top may be conveniently closed by an inverted pot saucer. This cage provides fairly good breeding conditions with a minimum of attention, but individual records are not obtainable under this method.

SEASONAL HISTORY

Seasonal history and distribution are closely interrelated. In general, it may be said that single-brooded species are of northern distribution, while multiple-brooded species have their center of abundance in the South. *Agrotis ypsilon* and *Lycophotia saucia* form exceptions to this rule, as discussed under "Distribution." Also, the species which pass the winter as pupae are limited to southern regions, with the exception of one obscure species, *Polia legitima*, and the two species named above; while the northern species, with these exceptions, pass the winter as larvae.

NATURAL CONTROL OF CUTWORMS

There are not sufficient data available to give anything approaching a complete solution of the problem of natural control for any cutworm species. Apparently the control of many multiple-brooded species is largely effected in the fall and winter in this latitude as discussed under "Distribution" (p. 3). Climatic agencies seem to be the main factors in this control, since the observed rate of mortality from parasites and disease is not as high in the multiple-brooded species as in the single-brooded. Their abundance is also more variable from year to year, possibly indicating that some variable factor, such as cold or rainfall, may play a very important part in the control of multiple-brooded species.

If we may assume that half the moths are females and that these deposit 200 eggs each, 99 per cent of the reproductive effort of a single-brooded species must be absorbed if the species is to be held at a constant level of abundance. It is impossible to evaluate the contribution of the various agencies toward control without definite knowledge of the percentage of emergence.

In larvae of *Feltia ducens* collected in April, when mature, and reared in a screen-wire cage set in a normal turf outdoors, there was an average mortality of 81.5 per cent for a period of four years. In 399 larvae of this species collected in April and reared singly in tin boxes there was a mortality of 80.5 per cent. This indicates that larvae reared thus in tin boxes are not under very abnormal conditions. In a collection of 618 larvae of four single-brooded species collected during April, May, and June, 1921, and reared singly in tin boxes there was a mortality of 92.3 per cent.

In all of the above breeding experiments some of the normal controlling agencies were hampered or excluded. If we may accept the above average mortality of 92.3 per cent as normal, then a reduction of only 7.6 per cent is possible if the species is to maintain itself, even if there is no mortality after emergence until the following April. Birds and other predators and climatic agencies will cut down this margin of 7.6 per cent in the several months which intervene before the moths emerge.

The nearer the mortality comes to 99 per cent in larvae collected in the spring, the more complete become the data as to the contribution of individual factors toward control. If 4 per cent emerge and oviposit, then about 75 per cent of the control is effected between September and April, and the agencies effecting this 75 per cent control are obscure, since the species are resistant to cold and cold checks the activities of most of their animate enemies.

It is a remarkable fact that through the operation of these various agencies, animate and inanimate, variable and less variable, some of the single-brooded species are held at an almost constant level of abundance over long periods.

INSECT PARASITES AND DISEASE

Insect parasites and disease are characterized by the fact that in the act of initiating the destruction of the insect attacked they make provision for the possible destruction of a very much greater number at some future time. Thus the disease which kills a single larva may develop reproductive bodies sufficient to infest a very large number, and a single host may produce sufficient parasites to destroy several hundred larvae in the next generation.

The great reproductive capacity of these agencies together with the more or less obligate character of their attack would seem to fit them especially for the control of the highly prolific multiple-brooded species; and their effectiveness in this respect under favorable conditions in periods of excessive abundance of the host is well known and sometimes gives these agencies the aspect of being a last resort of nature in suppressing rampant species. In spite of this fact the observed mortality due to insect parasites and disease in normal infestations of cutworms is not sufficient to account for more than a small percentage of the reproduction of which the cutworm species at this level are theoretically capable.

When the theoretical reproductive capacity of a multiple-brooded species like *Lycophotia saucia* is compared with that of a single-brooded species like *Feltia ducens*, it is seen that the chances are millions to one in favor of the multiple-brooded species. In spite of this fact many of our dominant species are single-brooded, and the observed mortality due to the insect parasitism and disease is decidedly higher in the single-brooded species than in the multiple-brooded forms. The mortality observed in rearing four multiple-brooded species and four single-brooded species is given below. The larvae were collected when nearly mature and reared under identical conditions in tin boxes with unsterilized field earth. The collections in both classes were distributed over April, May, and June, 1921, except that in *Feltia annexa* the larvae were collected from July to October, and these showed the lowest mortality of any.

The multiple-brooded species reared were *Lycophotia saucia* (110 larvae), *Polia renigera* (147), *Prodenia ornithogalli* (113), *Feltia annexa* (217). The single-brooded species were *Feltia gladiaria* (297), *Feltia ducens* (198), *Agrotis badinodis* (32), *Porosagrotis orthogonia* (91).

TABLE 1.—*Sources of mortality in multiple-brooded and single-brooded cutworms*

	Multiple-brooded species	Single-brooded species
Number of larvae reared	587	618
Moths emerged ... per cent	63.7	7.7
Mortality due to insect parasitism ... do	8.5	10.7
Mortality due to disease ... do	5.1	22.0
Mortality due to nematodes ... do	0.5	0.4
Mortality due to unknown causes ... do	22.1	59.0

A major portion of the mortality listed above as due to unknown causes probably may be credited, in the single-brooded species, as the toll which these species must pay for the long aestivating stage which is forced upon them, as discussed under "Distribution."

Host lists of the various insect parasites and disease organisms of cutworms, including all of the references which have come to the attention of the writer, are given in Tables 2, 3, and 4.

TABLE 2.—*Dipterous parasites of cutworms*

Parasitic species	Host species	Parasite determined by—
Anthrax alternata Say	Feltia venerabilis	Aldrich.
	Chorizagrotis auxiliaris	
A. hypomelas Macq	Feltia ducens-subgothica	
A. willistonii Coq. (?)	Chorizagrotis auxiliaris	
Aphiochaeta sp	C. auxiliaris	
Aphria ocypterata Town	Euxoa messoria	Coquillett.
Archytas analis Fab	Lycophotia saucia	Aldrich.
Bonnettia compta Fall	Feltia annexa	Do.
	F. venerabilis	Do.
	F. malefida	Do.
	Agrotis ypsilon	Do.
	Euxoa messoria	Do.
	Lycophotia saucia	Do.
Chaetogaedia monticola Bigot	L. saucia	Do.
C. analis V. d. W	Polia renigera	Do.
Ernestia sp	Chorizagrotis auxiliaris	
Frontina archippivora Will	Agrotis ypsilon	Coquillett.
Gonia fuscicollis Tot	Feltia ducens	Aldrich.
Gonia sp.[1]	Agrotis ypsilon	
G. capitata De G	Lycophotia saucia	
G. frontosa Say	Sidemia devastator	Do.
	Feltia ducens-subgothica	Do.
G. sequax Will	Lycophotia saucia	Do.
G. aldrichii Tot	Sidemia devastator	Do.
G. longipulvilli Tot	Feltia annexa	Do.
	Lycophotia saucia	Do.
Helicobia helicis Town	Feltia annexa	Do.
Linnaemyia picta Meig	Porosagrotis vetusta	Coquillett.
Madremyia saundersii Will	Lycophotia saucia	Do.
Paragaedia hedemanni B. B	Prodenia ornithogalli	Aldrich.
Peleteria robusta Wied.[1]	Chorizagratis auxiliaris	
Peleteria tessellata Fab.[1]	C. auxiliaris	
Phorichaeta sequax Will	do	Do.
P. cinerosa Coq. (?)	do	
Phorocera claripennis Macq	Feltia ducens-subgothica	Townsend.
	Agrotis c-nigrum	
	A. ypsilon	
	L. saucia	
Sarcophaga cimbicis Town. or S. latisterna Pk.	Euxoa messoria	Aldrich.
Tachinomyia robusta Town	Agrotis ypsilon	Coquillett.
Winthemia quadripustulata Fab	Lycophotia saucia	Aldrich.
	Feltia ducens-subgothica	Townsend.
	Agrotis c-nigrum	
	P. ornithogalli	Do.
	P. dolichos	
	P. eridania	
Zenillia formosa Ald. and Web	Agrotis ypsilon	Aldrich and Webber.
Z. eudryae Town	A. ypsilon	Coquillett.

[1] The group of species to which the name was originally applied has been divided and it is now impossible to determine the proper designation of the parasite in question.

TABLE 3.—*Hymenopterous parasites of cutworms*

Parasitic species	Host species	Parasite determined by—
Amblyteles subfuscus Cress	Chorizagrotis auxiliaris	Brues.
A. nuncius (Cress.)	C. auxiliaris	
A. seminiger (Cress.)	Agrotis c-nigrum	
A. longulus (Cress.)	Chorizagrotis auxiliaris	
Amblyteles sp	Polia renigera	Gahan.
A. suturalis (Say) var	Feltia ducens-subgothica	Viereck.
A. subrufus Cress	Chorizagrotis auxiliaris	
A. comes (Cress.)	Agrotis c-nigrum	
A. maurus (Cress.)	Lycophotia saucia	Ashmead.
A. cupitus (Cress.)	L. saucia	
A. jucundus Brullé	Sidemia devastator	
Apanteles griffinii Vier	Feltia gladiaria	Gahan.
	F. ducens-subgothica	Do.
	F. annexa	Do.
	Prodenia ornithogalli	Do.
A. laeviceps Ashm	Chorizagrotis auxiliaris	Do

TABLE 3.—*Hymenopterous parasites of cutworms*—Continued

Parasitic species	Host species	Parasite determined by—
A. parastichtidis Mues	Parastichtis bicolorago	Muesebeck.
Apanteles sp	Porosagrotis vetusta	
A. xylinus (Say)	Agrotis c-nigrum	Do.
A. yakutatensis Ashm	Agrotis c-nigrum	Do.
A. grenadensis Ashm	Prodenia eridania	Do.
A. forbesi Vier	Polia renigera	Do.
A. militaris Walsh	Feltia malefida	
Berecyntus (Copidosoma) celaenae How	Polia renigera	Gahan.
Berecyntus bakeri How. var. gemma Gir.	Sidemia devastator	Girault.
B. bakeri How. var. euxoae Gir	Chorizagrotis auxiliaris	Do.
Berecyntus sp	Feltia ducens-subgothica	Do.
Chelonus sp	Prodenia eridania	
Copidosoma sp	Chorizagrotis auxiliaris	
Enicospilus purgatus (Say)	P. ornithogalli	
	Feltia annexa	Do.
	Lycophotia saucia	
Ephialtes sanguineipes (Cress.)	L. saucia	Cushman.
Euplectrus bicolor Swed	Agrotis c-nigrum	
E. platyhypenae How	Prodenia ornithogalli	Viereck.
Hyposoter interjectus Gah	Prodenia ornithogalli	Gahan.
Limnerium sp	P. ornithogalli	
	P. eridania	
Lissonota americana (Cress.)	Sidemia devastator	
Litomastix (Copidosoma) truncatella Dalm.	Prodenia ornithogalli	
Meteorus autographae Mues	Feltia ducens	Do.
	Lycophotia saucia	Do.
	Prodenia eridania	Muesebeck.
Meteorus vulgaris Cress	Feltia subgothica	Do.
	F. ducens	Viereck.
	F. gladiaria	Gahan.
	F. annexa	Muesebeck.
	F. malefida	
	Agrotis ypsilon	Gahan.
	Chorizagratis auxiliaris	Do.
	Lycophotia saucia	Muesebeck.
Meteorus laphygmae Vier	Feltia annexa	Do.
	Lycophotia saucia	Do.
	Prodenia sp	Do.
M. dimidiatus Cress	Feltia ducens-subgothica	Viereck.
	Chorizagrotis auxiliaris	Brues.
	Sidemia devastator	Do.
Meteorus indagator Riley	Lycophotia saucia	Ashmead.
Microbracon erucarum Cush	Chorizagrotis auxiliaris	
Mirogaster sp	Chorizagrotis auxiliaris	
Microplitis kewleyi Mues	Euxoa sp	Muesebeck.
M. feltiae Mues	Feltia ducens-subgothica	Do.
	F. gladiaria	Do.
	F. annexa	Do.
M. varicolor Vier	Lycophotia saucia	Do.
Ophion idoneum Vier	Parastichtis bicolorago	Cushman.
O. bilineatum Say	Agrotis c-nigrum	Do.
	Prodenia ornithogalli	Viereck.
	P. eridania	
	Parastichtis bicolorago	Cushman.
	Agrotis ypsilon	Viereck.
	Feltia gladiaria	
	F. ducens	Cushman.
Paniscus geminatus (Say)	Agrotis badinodis	Do.
Paranomalon propinquum (Cress.)	Feltia ducens	Gahan.
Paranomalon sp. (?)	Chorizagrotis auxiliaris	
Rogas aciculatus Cress	Feltia ducens-subgothica	Viereck.
R. perplexus Gah	Lycophotia saucia	
Sagaritis provancheri (D. T.)	Prodenia ornithogalli	Cushman.
	Lycophotia saucia	Do.
S. consimilis (Ashm.)	Agrotis ypsilon	Do
Zele melleus Cress	Prodenia ornithogalli	Viereck.

TABLE 4.—*Organisms causing disease in cutworms*

Organism	Host	Organism determined by—
Beauveria sp.	Feltia ducens-subgothica	Speare.
	F. gladiaria	Do.
	F. annexa	Do.
	Polia renigera	Do.
	Agrotis badinodis	Do.
	Porosagrotis orthogonia	Do.
	Prodenia ornithogalli	Do.
Beauveria minimum Speg.	Polia legitima	Patterson.
Botrytis rileyi Farl.	Feltia ducens-subgothica	Speare.
	F. gladiaria	Do.
	Agrotis badinodis	Do.
Cordyceps sp.	Polia legitima	Do.
Empusa sp.	Prodenia eridania	Patterson.
Entomophthora aulicae Reich	Lycophotia saucia	Thaxter.
	Polia (Mamestra) sp.	Do.
Entomophthora megaspermum (Cohn)	Cutworm (A. Gibson)	Speare.
Entomophthora virescens Thax.	Agrotis fennica Tausch	Thaxter.
	Feltia annexa	Speare.
Entomophthora sp.	Feltia gladiaria	Do.
	Agrotis badinodis	Do.
Isaria farinosa Link	Nephelodes emmedonia	Do.
Isaria sp. (?)	Cutworm pupa	Do.
Metarrhizium anisopliae Sorokin	Feltia ducens-subgothica	Do.
	F. gladiaria	Do.
	F. annexa	Do.
	Porosagrotis orthogonia	Do.
Penicillium briardi Vuill. (?)	Feltia ducens-subgothica	Do.
	F. gladiaria	Do.
Sorosporella uvella (Krass.) Gd.	Euxoa tessellata	Do.
	Feltia gladiaria	Do.
	F. annexa	Do.
	F. ducens [1]	Do.
	Polia renigera	Do.
	Agrotis ypsilon	Do.
	A. badinodis	Do.
	A. c-nigrum [1]	Do.
	Lycophotia saucia [1]	Do.
Verticillium sp.	Polia legitima	Patterson.
Bacillus noctuarum White	Prodenia ornithogalli	White.
	Feltia annexa [1]	Do.
Bacteria (?)	F. ducens-subgothica	Speare.
	F. gladiaria	Do.
	Porosagrotis orthogonia	Do.
	Polia renigera	Do.
	Nephelodes emmedonia (violans)	Osborn.
	Chorizagrotis auxiliaris	Glaser.
Protozoa (?)	Feltia annexa	White.
	F. gladiaria	
	F. ducens-subgothica	
	Polia renigera	
	Lycophotia saucia	
	Agrotis badinodis	

[1] Infection was experimentally produced, but has not been observed in nature.

NOTES ON CUTWORM DISEASES

BEAUVERIA SP. (PL. 2, A)

A. J. Speare states in a letter that "possibly this is the common chinch bug fungus." The writer has obtained it in nature from *Feltia ducens*, *F. gladiaria*, *F. annexa*, *Polia renigera*, *Agrotis badinodis*, *Porosagrotis orthogonia*, and *Prodenia ornithogalli.* The external growth of this fungus consists of a spreading white mycelium which develops globular masses of spores, white at first and then yellowish, which arise from a meshwork of slender threads without noticeable stalks.

A heavy external growth of mycelium may be produced and spores ripened within a week after the death of the host, and spores may ripen in three or four days after the development of external mycelium. A larva of *F. gladiaria* infected May 5, 1921, had developed a thick vestiture of mycelium on June 18. Another larva of *gladiaria* which was dusted with spores on May 5 was alive May 25, but had died and developed a strong external growth of mycelium on June 4, which produced spores on June 7. A larva of *F. annexa* dusted with spores May 31 was dead June 4 and bore the fruiting stage of Beauveria on June 13.

THE MUSCARDINE FUNGUS (METARRHIZIUM ANISOPLIAE SOROKIN) (PL. 2, B)

The writer has obtained this well-known enemy of white grubs and wireworms in nature from *Feltia ducens*, *F. gladiaria*, *F. annexa*, and *Porosagrotis orthogonia*. The external growth arises as white, compact, close-cropped clumps of much-branched threads from which arise in a brief time chains of livid greenish spores so closely packed on end as to completely incrust the larva. The underlying white mycelium continues growth and, after cracking the crust of spores like dried mud, finally may break the spores into small isolated masses borne outward by the developing hyphae.

Spores may be formed within two days after the appearance of external mycelium. A larva of *F. annexa* dusted with spores May 31 was dead June 4, was invested in white mycelium on June 10, and was covered with greenish spores on June 13.

SOROSPORELLA UVELLA (KRASS.) GD.

Natural infection by this fungus was observed in *Feltia gladiaria*, *F. annexa*, *Polia renigera*, *Agrotis badinodis*, and *A. ypsilon*. The occurrence and characteristics of this organism have been fully treated by Speare (*66*, *67*).

No external growth is produced. The affected larvae may be found disintegrating under rubbish or in the soil with the body filled with free aggregations of brick-red spores which appear to the naked eye as a reddish powder.

BOTRYTIS RILEYI FARL. (PL. 2, D)

The writer has observed natural infection by this fungus in *Feltia ducens*, *F. gladiaria*, and *Agrotis badinodis*. In larvae killed by this disease a white external growth appears shortly after the death of the host. In a few days this becomes more and more tinged with green until in the mature fruiting stage the larva is more or less completely invested in a mossy green growth which, with the least disturbance, gives off a miniature cloud of green spores that soon coat adjacent objects. A larva of *F. ducens* killed by this disease was found in the field attached to a weed stem among rubbish on the ground.

Ten larvae each of *F. gladiaria* and *F. ducens*, most of which had recently molted, were moistened and dusted with spores on April 7. Two larvae died on April 9, and a few appeared to be sick on April 11. These began dying on April 18 and continued to die until May 3, when but four larvae remained alive. White mycelium appeared on two larvae on April 24. This mycelium was faintly tinged with green on April 25 and was more distinctly green on the following day, indicating that spores were developing. A larva which died

April 25 was invested in mycelium two days later. All stages in the development of the external growths, from larvae of rubbery consistency without external growth to those bearing white mycelium and others displaying ripe spores, were present May 3. Six larvae developed the fruiting stage of the disease.

PENICILLUM SP. (PL. 2, I)

Speare states in a letter that this may be *Penicillium briardi* Vuill. The writer has observed natural infection by this species in *Feltia ducens* and *F. gladiaria*. The external growth arises from a sparse white mycelium apparently consisting merely of the penetrating hyphal stalks from the internal growth. These stalks each bear 2 to 12 or more chains of round, pale brownish spores, all of the chains arising from about the same point on the pedicel. To the naked eye a larva invested in this growth appears to be covered with a pale brownish-gray coating like dust. The writer has not succeeded in infecting larvae with this disease. There is a Penicillium with white spores which occurs very commonly as a saprophyte on larvae.

ISARIA SP. (PL. 2, C)

The writer has noted infection apparently by Isaria in a cutworm pupa, and *Isaria farinosa* Link occurs among larvae of *Nephelodes emmedonia*. These diseases are characterized by the hyphal fascicles which appear above ground and by the slender, tough, rootlike growths which penetrate the soil about the host.

FUSARIUM SP. (PL. 2, H)

Fusarium has been obtained by the writer from larvae of *Feltia gladiaria*, but Speare considers that it is questionable whether or not it is parasitic. The external growth arises as a white mycelium.

CORDYCEPS SP.

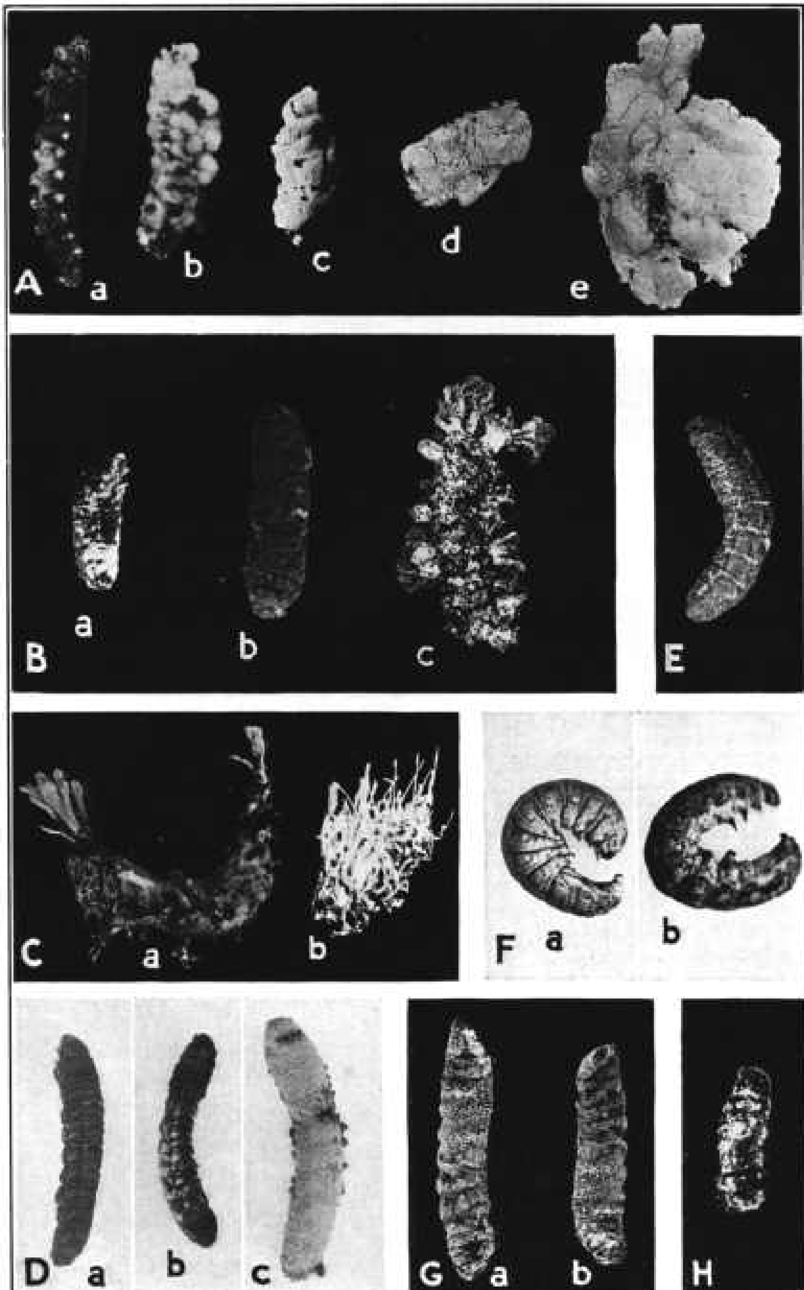
A single larva of *Polia legitima* collected March 22 is the only cutworm affected by Cordyceps which has come to the writer's attention. In this larva the body was somewhat contracted but of about normal girth. It was hard like wood, with the skin intact; the colors were faded but recognizable; and the skin was punctured dorsally at both extremities by a sproutlike outgrowth about an inch long.

UNDETERMINED FUNGOUS DISEASES (PL. 2, E)

In the case of several larvae of *Feltia gladiaria* which died in June, 1921, no fruiting stage could be obtained by Speare, and he expressed the opinion that the disease might require a resting stage and that it might prove to be Cordyceps. These larvae were of a stiff, rubbery character, were reddish brown in color, developed no external growths, and were filled with fungus hyphae.

PROTOZOAN DISEASE (PL. 2, F)

There is an affection of cutworms in which the venter becomes dull waxy white and the larva becomes sluggish and discharges a watery material. Death may not take place for a considerable time after these symptoms appear. This condition has been observed in larvae



DISEASES OF TOBACCO CUTWORMS

(See reverse side fo8 complete legend.)

DISEASES OF TOBACCO CUTWORMS

A, Stages in development of Beauveria sp.: *a*, very early stage in development of external mycelium on larva of *Feltia ducens; b*, strongly spreading clumps of mycelium in an early stage of growth on larva of *Polia renigera; c*, early stage of spore formation on larva of *Porosagrotis orthogonia; d*, mature yellowish-white spores on larva of *F. gladiaria; e*, late fruiting stage, after the mycelium has spread widely over the soil about the larva attacked (*F. ducens*).

B, Stages in development of *Metarrhyzium anisopliae: a*, dense close-cropped clumps of much-branched mycelium on larva of *Feltia gladiaria*, spores not developed; *b*, larva of *F. gladiaria* encrusted with spores, the convex areas representing the underlying clumps of mycelium; *c*, the crust of spores broken into small portions which are borne outward by the developing mycelium.

C, Isaria spp.: *a, Isaria farinosa* on larva of *Nephelodes emmedonia* showing the rootlike subterranean outgrowths and the spore-bearing hyphal fascicles; *b*, Isaria sp. developing on a cutworm pupa.

D, Stages in development of *Botrytis rileyi* on larvae of *Feltia ducens: a*, larva with only a trace of external mycelium; *b*, larva showing further development of external mycelium; *c*, larva invested in mossy green spores.

E, Unknown fungous disease attacking larva of *F. gladiaria;* the pale spots are due to earth adhering to the larva.

F, Protozoan infection (?): *a*, in larva of *Feltia ducens; b*, in larva of *Lycophotia saucia.*

G, Spores of Penicillium sp. (*briardi* Vuill.?) on larva of *Feltia gladiaria.*

H, External mycelium of Fusarium sp. on larva of *Feltia gladiaria.*

(The diseases affecting the larvae here shown have been determined by Alden T. Speare, with the exception of those illustrated in F.)

of *Feltia ducens*, *F. gladiaria*, *F. annexa*, *Polia renigera*, *Lycophotia saucia*, and *Agrotis badinodis*. Whether more than one disease is responsible for these symptoms is not known, but larvae of *F. annexa* so affected were submitted to G. F. White, who tentatively diagnosed the disease as due to protozoan infection, the parasite belonging probably to the class Sporozoa.

WILT DISEASE

Chapman and Glaser (*9*) note the occurrence of wilt disease in larvae of *Prodenia litosia* in Europe. With regard to the symptoms of wilt these writers state:

> The wilt is characterised by the formation in the bodies of infected caterpillars of polyhedral-shaped, highly refractive, angular bodies, which have their origin in the nuclei of the tracheal matrix, hypodermal cells, fat cells and blood corpuscles. Later some of these burst and the polyhedra are set free in the blood. When death results they make up a great part of the saponified body tissues of the caterpillars. The caterpillars hang by their prolegs, become flaccid, and their skin disrupts at the slightest touch. An examination immediately after death reveals few or no bacteria and no bad odor. The wilt appears in nature in both a chronic and an acute form. If, however, a dead caterpillar, on microscopic examination, shows no polyhedra it does not have wilt, even though all the gross symptoms may be present.

In a previous article (*35*) these writers also state that the exciting cause of wilt is a filterable virus and that infection normally takes place by the ingestion of the causal agency with the food.

SEPTICEMIA

White (*82*) describes a disorder of cutworms, under the name of cutworm septicemia, which the writer has found to be very prevalent among larvae of *Prodenia ornithogalli* in nature. White defines this disorder as follows:

> If cutworms seem sluggish, cease to feed, and die, and the remains become soft and turn brown to almost black, cutworm septicemia may be suspected. The disease may be more strongly suspected if healthy worms inoculated with material from dead ones show symptoms and post-mortem changes which have been noted for the disorder. To make a positive diagnosis, however, it is necessary to demonstrate the presence of *Bacillus noctuarum* in the sick larvae or the remains of those recently dead. Microscopic preparations made from worms sick or recently dead of the disease will contain numerous, short, non-spore-bearing rods. Agar plates streaked with the tissues of such worms will show in 24 hours at room temperature a well-defined bluish gray growth of an actively motile bacillus.

The source of infection in nature is not known, but the writer's experiments indicate that infection seldom takes place when food smeared with diseased tissue is eaten. He has also smeared the infected tissue on the skin and spiracles of larvae without producing the characteristic symptoms. In short, he has only succeeded in producing the malady consistently by inoculating diseased tissue or an agar culture of such material into the larva with a needle.

The following records from the writer's experiments will serve to indicate the method pursued and the results obtained. The larvae were confined singly in sterilized tin boxes and were fed upon tobacco. Larvae of *Feltia annexa* were used in the experiments because of their abundance and also for the reason that they seem to be rarely attacked by this malady in nature, thus reducing somewhat the chances of previous infection in the experimental material.

Experiment begun August 22, 1917, 11 a. m.

Lot 1. Five larvae punctured with a sterile needle.
Lot 2. Five larvae inoculated with an agar culture of the Prodenia disease.
Lot 3. Five larvae with food smeared with the above culture.

Examination of August 23, 9 a. m.:
Lot 1. Normal in appearance.
Lot 2. Normal in appearance.
Lot 3. Normal in appearance.

Examination of August 24, 9 a. m.:
Lot 1. Normal in appearance.
Lot 2. Four dead, one alive.
Lot 3. Normal in appearance.

Examination of August 25, 10 a. m.:
Lot 1. Normal in appearance.
Lot 2. Four dead, one alive.
Lot 3. Normal in appearance.

Experiment begun August 22, 1917, 12 m.

Lot 1. Three larvae punctured with sterile needle.
Lot 2. Three larvae inoculated by needle with an agar culture of the disease.
Lot 3. Four larvae with food smeared with culture of the disease.

Examination of August 23, 9 a. m.:
Lot 1. Normal in appearance.
Lot 2. Two dead, one alive.
Lot 3. Normal in appearance.

Examination of August 24, 9 a. m.:
Lot 1. Normal in appearance.
Lot 2. Three dead.
Lot 3. One dead, three alive.

Examination of August 25:
Lot 1. Normal in appearance.
Lot 2. Three dead.
Lot 3. Two dead (one parasitized), two alive.

Examination of August 28: No change.

Experiment begun August 23, 1917, 11.30 a. m.

Lot 1. Five larvae inoculated by needle with diseased tissue several days old.
Lot 2. Five larvae inoculated by needle with an agar culture of the disease.
Lot 3. Five larvae with food smeared with diseased tissue.

Examination of August 24, 9 a. m.:
Lot 1. Normal in appearance.
Lot 2. Normal in appearance.
Lot 3. Normal in appearance.

Examination of August 25, 9 a. m.:
Lot 1. One dead, four alive.
Lot 2. Five dead.
Lot 3. Normal in appearance.

Examination of August 26, 6 a. m.:
Lot 1. Two dead, three alive.
Lot 2. Five dead.
Lot 3. One dead, four alive.

Examination of August 28: No change.

PREDATORS

Predators are theoretically less effective than parasites in that a given number of individuals of the former is incapable of initiating nearly as much destruction as a similar number of the latter type of cutworm enemies. The predator kills for food while the parasite attacks to reproduce. The effectiveness of predators is also reduced owing to the diffuse character of their attack, which is extended over a long period, as compared with the concentrated and more or less obligate attack of parasites. On the other hand, predators are not compelled to share the vicissitudes of the insects attacked as is the case with parasites.

Predators thus have the appearance of being a clumsy instrument especially fitted to aid in the maintenance of the balance of nature by feeding more or less indiscriminately on the most abundant food species, and entirely incapable of keeping pace with the high rate of reproduction found in many cutworm species. Hunter (*38*), Smith (*62*), and Burgess (*7*) give instances, however, of sensitiveness of response, mobility, and numbers in species of Calosoma which give their contribution to the control of local outbreaks of insects something of the character of the control effected by parasites. Similar characteristics will probably be found in other less conspicuous predacious genera. Very probably the importance of predators in cutworm control has been underrated.

During April, 1921, 50 plats of 1 square yard each were examined to a depth of 3 inches with regard to the predatory and food species present. An attempt was made to collect everything with the exception of such minute forms as springtails and some small leaf hoppers and flies. The plats were systematically selected from different types of cover and were well distributed over an area about Clarksville, Tenn., having a radius of about 5 miles. The number of predators, food species, and neutral insects found in the various types of cover examined is calculated to an acre basis in Tables 5, 6, and 7. Averaging the totals in the six types of cover gives 62,386 predators per acre, counting ant hills as single units, and 266,881 food units, including 191,783 earthworms whose status as food is uncertain, giving somewhat more than four food units for each predator.

TABLE 5.—*Possible food species of predators found near Clarksville, Tenn., in April, 1921*

Food species	Number per acre in various types of cover					
	Corn stubble	Tobacco stubble	Forage crops	Pasture land	Truck crops	Waste land
Cutworms	4,494	968	8,066	22,000	9,680	15,325
Miscellaneous lepidopterous larvae	690	0	3,226	19,800	2,420	8,065
Wireworms (elaterid larvae)	3,111	3,872	3,629	3,960	9,680	3,226
White grubs	5.876	0	4,839	18,040	26,620	7,259
Weevil larvae	1,382	5,808	14,921	14,960	2,420	4,839
Tipulid larvae	0	0	6,452	10,120	53,240	806
Miscellaneous dipterous larvae	691	968	806	2,540	0	2,419
Chrysomelid larvae	0	1,936	6,856	17,160	0	12,099
Miscellaneous Homoptera	17,285	4,840	2,016	2,640	0	0
Orthoptera	4,147	1,936	5,645	3,080	0	2,419
Miscellanous food units	20,335	0	403	0	0	0
Earthworms	81,139	30,008	126,636	229,680	559,020	124,216
Snails, slugs, millipedes, etc	1,728	0	9,679	6,600	21,780	806
Total	140,878	50,336	193,174	350,580	684,860	181,479

TABLE 6.—*Invertebrate predators found near Clarksville, Tenn., in April, 1921*

Predators	Number per acre in various types of cover					
	Corn stubble	Tobacco stubble	Forage crops	Pasture land	Truck crops	Waste land
Ant hills	2,074	1,936	1,613	5,280	4,840	4,839
Medium to large spiders	12,445	3,872	11,695	11,880	26,620	11,292
Small spiders	8,296	8,712	16,132	18,480	33,880	7,259
Carabid larvae and pupae	3,802	968	3,226	7,480	9,680	0
Chilopods	3,802	0	2,823	2,200	9,680	0
Miscellaneous coleopterous larvae	345	3,872	1,614	440	0	0
Anisodactylus spp	4,494	2,904	7,859	3,960	19,360	1,613
Amara spp	1,037	0	1,613	3,960	9,680	4,839
Carabids 95 per cent carnivorous [1]	1,382	2,904	2,420	2,200	4,840	2,420
Patrobus and Harpalus	345	0	403	440	2,420	0
Agonoderus spp	4,839	968	1,613	1,320	0	806
Carabids 75 per cent carnivorous [2]	3,105	968	2,418	880	2,420	1,612
Miscellaneous predators	690	7,744	4,433	2,200	14,520	1,612
Total	46,656	34,848	57,862	60,720	137,940	36,292

[1] This group includes Calosoma, Platynus, Pterostichus, Chlaenius, and Bradycellus. The percentage of animal food given is a rough estimate.
[2] This group includes Dyschirius, Clivina, Panagaeus, Casnonia, Oodes, Cratacanthus, Stenolophus, Notiophilus, and Poecilus. The percentage of animal food given is a rough estimate.

TABLE 7.—*Neutral insects found near Clarksville, Tenn., in April, 1921*

Neutral insects	Number per acre in various types of cover					
	Corn stubble	Tobacco stubble	Forage crops	Pasture land	Truck crops	Waste land
Miscellaneous beetles	9,315	12,584	10,478	13,640	12,100	7,254
Staphylinids [1]	3,450	2,904	3,224	3,080	16,940	0
Hemiptera	8,625	34,848	10,881	3,080	7,260	8,866
Total	21,390	50,336	24,583	19,800	36,300	16,120

[1] The Staphylinids are predacious to some extent.

INVERTEBRATE PREDATORY ENEMIES OF CUTWORMS

The following invertebrates are known to be predatory on cutworms. The names of observers are given in parentheses after the names of the predators.

COLEOPTERA

Calosoma scrutator Fab., *C. reticulatum* Fab., *C. lugubre* Lec. (these three species of Calosoma have been observed to feed upon cutworms only in confinement, Burgess and Collins); *C. semilaeve* Lec. (H. M. Russell); *C. cancellatum* Esch. (G. E. Bensel); *C. calidum* Fab. (A. Fitch); *C. perigrinator* Guér. (A. W. Morrill); *C. sayi* Dej. (Chittenden and Russell); *C. tepidum* Lec. (E. H. Strickland); (*Calosoma*) *Callisthenes zimmermanni* (Lec.) (Strickland); *Chlaenius erythropus* Germ. (S. A. Forbes); *Galerita janus* Fab. (Forbes); *Geopinus incrassatus* (Dej.) (G. H. French); *Harpalus caliginosus* (Fab.) (A. Gibson); *H. erythropus* Dej. (S. E. Crumb); *Hister sexstriatus* Lec. (D. W. Coquillett); *Poecilus chalcites* Say (Crumb); (*Pterostichus*) *Poecilus lucublandus* Say (E. M. Patch); Pterostichus spp. (larvae, determined by Böving) (Crumb); *Scarites subterraneous* Fab. (F. H. Chittenden); cicindelid beetles (Strickland); staphylinids (Patch); lampyrid larvae (Crumb); coccinellid larvae (Crumb).

HYMENOPTERA

Formica fusca L. (S. E. Crumb); *F. sanguinea* Latr. (E. H. Strickland); *Polistes annularis* L. (Chittenden and Russell); *Psammophila luctuosa* Smith (A. Gibson).

HEMIPTERA

Podisus mucronatus Uhl. (Chittenden and Russell); *P. maculiventris* Say (Syn., *spinosus* Dallas) (C. V. Riley); *Stiretrus anchorago* Fab., var. *diana* Fab. (Chittenden and Russell).

SPIDERS

The writer has taken the following species feeding on cutworms: *Lycosa helluo* Walck., *L. fatifera* Hentz, *Pardosa milvina* Hentz, *Xysticus nervosus* Banks, *X. ferox* Hentz, *Lathrodectes mactans* Fab., *Marpissa undata* DeGeer, *Thanatus lycosoides* Emerton, *Phidippus audax* Hentz, and *Misumessus asperatus* Hentz (feeding on a moth).

MITES

Uropoda americana Riley (G. H. French); Uropoda sp. (S. E. Crumb).

Birds in Relation to Cutworm Control

Bird counts made under the direction of the Bureau of Biological Survey indicate that farm land, in distinction from woodland, supports an average bird population of about 122 pairs for each hundred acres in northern tobacco-growing regions. For the southern tobacco-growing area the data are unsatisfactory, but they indicate that an average bird population of about 131 pairs for each hundred acres is found. It is recorded that 88 species of southeastern birds feed upon cutworms. Judd (*42*) states that all species of birds "that are in the slightest degree insectivorous and feed at all on the ground show a marked liking for cutworms," and adds, after examining the stomachs of 645 specimens of common birds, that lepidopterous larvae constitute a yearly average of 7.8 per cent of the diet and that cutworms and other noctuid larvae are the forms most often found.

May is the month during which cutworms do the most conspicuous damage under normal conditions, and it is during this month that birds are found to feed most on lepidopterous larvae. The destruction of cutworms at this season is of twofold value, since it results in an immediate saving of plants and also cuts off at its source a portion of the stream of progeny which the multiple-brooded species are capable of producing in increasing volume as the season advances.

Table 8 is based on the thorough analyses of food habits of birds published by the Bureau of Biological Survey. It will be noted that cutworms and other lepidopterous larvae constitute an average of over 20 per cent of the food of this group of common species in May.

TABLE 8.—*Percentage of cutworms and other lepidopterous larvae in the food of birds*

Species	Percentage in May	Yearly average	Stomachs examined	Species	Percentage in May	Yearly average	Stomachs examined
			Number				*Number*
Chipping sparrow	43.25	14.2	---------	Bluebird	[1] 18.82	---------	855
Cardinal or red bird	26.7	5.98	498	Bobolink	17.6	13.0	291
Meadow lark	24.0	---------	1,514	Carolina wren	---------	21.73	291
Robin	23.96	9.04	1,236	Bobwhite	4.0	0.95	918
Redwinged blackbird	20.0	5.9	1,083	Crow	2.71	1.56	1,340

[1] March.

Judd has further pointed out (*41*) that many species of birds which subsist largely on a vegetable diet as adults, such as the crow blackbird, catbird, brown thrasher, and many sparrows, feed their nestlings largely on an animal diet, a large portion of which consists of cutworms and other lepidopterous larvae. With regard to the importance of this factor he states:

The amount of food consumed by nestling birds is not generally appreciated. The number of broods and of young vary according to the species and the region under consideration, but it is safe to say that on the average 2 or 3 broods of 3 to 5 each are raised every season. The young, from the time the eggs are hatched until the last offspring has left the nest, demand the most constant and untiring industry on the part of the parents. The labor of feeding begins before sunrise and continues with little rest until after sunset. Meals are very frequent, often averaging one every two minutes. At first the nestlings consume more than their own weight of food in a day, and make a daily gain in weight of 20 to 50 per cent. At this time they appear to consist of little else than mouth and stomach, and spend nearly all their waking moments in eating. The total of the material required is astonishingly large. A robin kept in captivity by Professor Treadwell required 60 earthworms a day, and the young of a pair of European jays, observed by Doctor Brewer, were fed half a million caterpillars in a single season.

CLIMATIC AGENCIES

Climatic agencies are universal in their attack but selective in action according to the varying resistance the species are able to offer. Numbers present no problem to these agencies, and they are independent of the vicissitudes of the species affected, but any given factor is intermittent and variable in occurrence and degree.

COLD

As evidence of the importance of cold in limiting the distribution of cutworm species it may be noted that single-brooded species in general have their seat of abundance in the North and are resistant to cold in all their stages; whereas multiple-brooded species in general (with some notable exceptions) have their metropolis in the South, are not very resistant to cold until they reach the pupal stage, and are usually not very highly resistant even then.

The writer's records show that the percentage of mortality due to insect parasites and disease is higher for single-brooded species than for multiple-brooded species and that the former are less prolific individually than the latter. The chances are millions to one in favor of the multiple-brooded species on the basis of reproductive capacity. Yet the dominant species in the North are mostly single-brooded.

Some factor other than parasitism, disease, or fecundity operates to the advantage of the cold-resistant single-brooded species in the North. The operation of cold in limiting the distribution of species is discussed under "Distribution."

In addition to limiting the distribution of species, cold may be an important factor in reducing the numbers of all species. The writer has kept larvae of *Feltia ducens* out of doors in zero weather until they clinked like pieces of icicle when moved, and yet with the abrupt return of a day that melted snow in protected spots they were again active and feeding apparently as sound as ever. Nevertheless it is certain that a considerable mortality due to fluctuating temperatures occurs even among the larvae which normally overwinter successfully, and in extremely severe winters this mortality materially reduces the numbers of even the most resistant species. Thus, after the winter of 1917, which for prolonged severe cold was the worst in a generation, nearly all cutworm species occurred in notably lessened numbers.

Heat

Heat, even without being injurious to cutworms, in itself, is probably of great importance in limiting the southern distribution of many cutworm species, as discussed under "Distribution."

Rain

The writer's observations include several clear instances of the absence of cutworms after excessive rains, where they had been abundant a few days before, and in some cases he has found larvae dead in the soil. The conditions prevailing in 1919 present an example of a general reduction in the numbers of *Feltia annexa* and *Lycophotia saucia*, apparently due to the drowning of the overwintering pupae. Larvae of these species were of normal abundance in the fall of 1918, as shown by collecting records for these species covering a number of years; but in the fall of 1919, in places where hundreds of larvae might have been collected under normal conditions, scarcely 10 could be found in half a day. The weather records show that climatic conditions in the period during which larvae had been developing and entering the soil for pupation in the fall of 1918 were quite favorable, and the only outstanding feature of the season of 1919 was the very excessive rainfall during March, May, and June.

Nearly 10 inches of rain fell during March and 5 inches fell in 24 hours, March 16–17. During May it rained 21 days, the precipitation of 10.74 inches being the greatest, with one exception, that had occurred at Clarksville, Tenn., in 37 years, and the rain continued through the first 11 days of June. The larvae of both species were still scarce in the fall of 1920, and only became common in the fall of 1921.

Drought

Drought might be expected to have a decided influence on the numbers of any larvae, such as cutworms, which are mainly dependent on succulent vegetation for food, but these inferences are not sustained by observation, since the summers of 1913 and 1914 were the driest in a generation, everything on the ground being burned brown, and yet cutworms were of normal and even supernormal abundance in the spring following 1913 and were only slightly less abundant in the spring following 1914. It may be that drought is injurious to cutworms but that it is accompanied by preponderant benefits, such as reduction in disease and reduction in the number of predatory enemies.

Two species of cutworms are fitted to escape the evil effects of drought, owing to an ability to develop on dry vegetation. *Feltia annexa* has been reared to maturity on such material and *F. malefida* has shown a like capability.

CONSIDERATION OF THE SPECIES

Unless otherwise stated, the observations recorded in the following pages have been made at the tobacco-insect laboratory at Clarksville, Tenn.

THE FELTIA GROUP

GENERAL CHARACTER OF LARVAE

This group includes the larvae of Feltia and of Agrotis as typified by *Agrotis ypsilon*. In these larvae the adfrontal sutures terminate in the occipital foramen; and the fuscous or ferruginous coloration of the head shield is disposed in a reticulated pattern (fig. 4, B) instead of in isolated flecks as in the Euxoa group (fig. 4, A). Some of the species are further distinguished from larvae of the Euxoa group by the coarse, isolated, strongly convex or conical skin granules. (Fig. 4, F–H.) These granules are fine and set contiguously like the blocks in a pavement in the Euxoa group. (Fig. 4, J.)

The larvae with coarse, isolated skin granules include *annexa*, *ducens*, *subgothica*, and *ypsilon*, while *malefida*, *gladiaria*, and *venerabilis* have the skin granules small and set contiguously. Whether or not these two groups represent the true affinities of the species is a question. Certainly *gladiaria* and *venerabilis* in the one section and *ducens* and *subgothica* in the other are respectively closely related, but the relationships of the remaining species are less evident.

THE GREASY CUTWORM, AGROTIS YPSILON Rott.

DISTRIBUTION

Agrotis ypsilon occurs throughout the United States, although its ravages have brought it most often into economic literature in the region east of the Mississippi River and in the contiguous States on the west. It also occurs throughout the southern part of Canada and in Mexico, Hawaii, South America, Europe, Egypt, Rhodesia, much of Asia, the East Indies, New Zealand, and Australia.

FOOD PLANTS

The known food plants include asparagus, apple, bean, beet, cabbage, castor bean, cauliflower, chick-pea, clover, cotton, corn, cucumber, cypress vine, grape, grass, lettuce, *Malva borealis*, morning glory, onion, orange seedlings, peach sprouts, pepper, potato, radish, Russian thistle, spinach, squash, strawberry, tobacco, and tomato.

Food Habits and Larval Habits

Agrotis ypsilon is one of the most pernicious of all cutworms, owing to the fact that it is very restless and after cutting off a plant will often wander away to repeat the damage again and again. It has received much notice in economic literature, including reports of injury to a wide range of field and garden crops, but seldom appears in such overwhelming hordes as some other species. R. H. Petitt, in a letter to the writer, stated, however, that upon one occasion 13 gallons of larvae were collected by hand as a sample. These larvae occurred in a beet field near St. Charles, Mich.

Lintner (*43*) also records an outbreak during which larvae of this species destroyed a large acreage of onions on muck land in New York. A serious outbreak of this species occurred in 1908 in the Wabash and Ohio River bottoms about Mount Vernon, Ind., and in adjacent parts of Kentucky and Illinois, during which hundreds of acres of corn were destroyed, causing an estimated damage of $200,000.

Forbes (*28*) considers this to be one of the commonest corn cutworms in Illinois, and Quaintance (*52*) states that it would seem that this species is the more common insect destructive to tobacco in Florida. The writer has found it rather uncommon in tobacco fields in the spring but common in the fall. Jones (*40*) found that 3.2 per cent of the cutworms taken injuring plants in Louisiana in three seasons belonged to this species.

The climbing habit is little developed, but after tobacco plants are too large to be cut down these larvae occasionally climb the plants and cut off the leaves. They are very ferocious, biting severely when shut up in the hand, and are highly carnivorous, finding flesh nearly or quite as palatable as green vegetation. They prefer rather moist soil and are not deterred by its being firm. Here they are usually found in open tunnels, often 3 or 4 inches beneath the surface, in which they lie extended. These cutworms are usually especially numerous in the fall in tobacco planted in moist "sink holes," such as occur commonly in Tennessee, suggesting the probability of a preference of the ovipositing moth for such situations. Davis (*21*) arrived at a similar conclusion in view of conditions in overflowed land in Indiana, and Woodhouse and Fletcher (*83*), from their observations in India, concluded that the mud left after floods recede has a special attraction for the ovipositing moths.

Seasonal History

Agrotis ypsilon is four-brooded in northern Tennessee. Moths of the first or overwintering brood emerge from about the middle of March to the first of May. Mature larvae from these are first found about the middle of May. Second-brood moths emerge from the latter part of May to the middle of July. Third-brood moths emerge from about the middle of July to the last of August. Fourth-brood moths make their appearance the first of September and continue to emerge into December and produce the overwintering generation.

The data upon which the above outline of the seasonal history of this species is based include breeding records on three consecutive generations of moths, bait-trap records covering a series of four years, and a very large amount of field collecting of larvae at all seasons.

Lintner (*43*) states that moths were taken on May 30, observed on every night during June, July, and August, and on more than half the nights in September, and continued to fly until the last week in October. Gibson (*33*) furnishes data very similar to the above and adds that eggs collected July 23, 1911, hatched July 27; that the larvae were mature August 20 and all entered the soil a few days later; and that the moths appeared from September 14 to 18. He also states that the number of broods is not definitely known but that there are probably two broods. Riley (*54*) considered that there were two broods. He records that moths were present in Massachusetts in April, August, September, and October; that mature larvae were taken at St. Louis about May 1 in several years; and that these did not produce moths earlier than July. Forbes (*28*) states that the winter is passed chiefly in the larval stage, the larvae continuing their activity into June or even into July, though most destructive in late May and early June. Gillette (*34*) reports that moths were taken from May 21 to October 18, inclusive, and considers that some of the moths overwinter before depositing eggs. Quaintance (*52*) states that in mild winters in Florida larvae are found from early fall to late spring.

OVERWINTERING STAGE

All attempts to carry larvae through the winter in an unheated room have failed, even when the tumblers were wrapped in cloths and the fluctuations of temperature were not unusual. But such conditions may be more severe than would occur under weed litter and soil outdoors, and all that can be said is that under the conditions prevailing in northern Tennessee successful hibernation in the larval stage seems very doubtful. The writer has never collected a larva under conditions which in any wise indicated that it might have overwintered. Pupae have been repeatedly carried through the winter, and this is evidently the normal stage in which the winter is passed in the latitude of Clarksville, Tenn. The egg may be safely eliminated from consideration as a possible means of passing the winter, since eggs continue to hatch up to at least the middle of November. All the evidence indicates that the moths do not hibernate successfully. The writer has attempted to overwinter moths which emerged about the middle of November under several conditions, both indoors and outdoors, without success, and bait-trap records and field collecting give no evidence to support the view that moths hibernate. The number of individuals used in the above experiments was small, however, and it is possible that the adults do sometimes survive the winter under conditions more nearly fulfilling their requirements.

DESCRIPTION OF STAGES

ADULT

The moth (pl. 4, B) is characterized by the long, narrow, usually dark, forewings, which are pale subapically and are marked with three black dashes, one from the middle of the outer side of the reniform spot and the other two directed toward this one from near the outer margin of the wing. Hind wings white with the veins and a broad indefinite margin dark. Expanse from about 1½ inches to 2 inches.

EGG

The egg is white, circular in outline, bluntly subconical in profile, 0.43 to 0.50 mm. high and 0.55 to 0.58 mm. broad, with about 35 to 40 moderately prominent, slightly sinuous ribs, the long and short ribs alternating irregularly, and with faintly indicated transverse lines. The second day after deposition a belt and micropylar splotch of brownish appear, and late-fall eggs are almost entirely suffused with reddish brown.

The eggs are said to be deposited in masses, and the writer has occasionally found them deposited thus in confinement and partially covered by scales from the body of the moth, but in breeding cages the eggs have usually been deposited singly or only a few together and glued rather firmly to the support without any trace of scaly covering. Maxwell-Lefroy and Ghosh (*44*) state that the eggs are deposited 1 to 30 in a place on leaves and stems near the ground.

LARVA

Agrotis ypsilon differs from the species of Agrotis of the *c-nigrum* group in the following important particulars and can not be included with them in any systematic arrangement:

Agrotis ypsilon:
- Adfrontal sutures terminating in the occipital foramen.
- Mandibles without an internal tooth.
- Arrangement of head setae and character of skin, spinneret, crochets of prolegs, labial palpi, and coloration as in Feltia.
- Blade of maxillulae with about 30 flat teeth.

Agrotis c-nigrum and allies:
- Adfrontal sutures terminating distinctly before reaching the occipital foramen.
- Mandibles with a large internal tooth.
- Arrangement of head setae and character of skin, spinneret, crochets of prolegs, labial palpi, and coloration of a distinctly different type from that found in Feltia.
- Blade of maxillulae with about eight terete teeth.

Agrotis ypsilon is a Feltia in all essential characters of the larva, although certainly of a quite distinct type. It may be readily distinguished by the very large, isolated, convex skin granules and the extra-large size of tubercle II, which is somewhat transverse and three times as large as tubercle I. The body is of unusually uniform width and has a peculiar loose-jointed appearance. The color is of a nearly uniform shade throughout above the spiracles, and varies from the more ordinary very dark shade to pale gray.

First instar.—Head 0.31 mm. broad. Body about 3.5 mm. long and 0.82 mm. broad, first four abdominal segments of about equal width, the body tapering both anteriorly and posteriorly from these, set rather closely with minute, isolated, subconical, chitinous granules, all above the spiracles overlaid considerably with orange. Head, anal and cervical shields, and legs dark fuscous, the head shield darkest. Setigerous tubercles I and II of abdomen of equal size, III, IV, and V much smaller and of about equal size, tubercle VI with a very long seta, other tubercles with very short, clavate setae not over one-third as long as an abdominal segment. Prolegs on abdominal segments 5, 6, and 10. Anal shield not emarginate.

Second instar.—Head 0.50 to 0.53 mm. broad. Body about 5.3 to 6.2 mm. long and 1.1 mm. broad, of practically uniform width throughout, set closely with rounded, rather coarse granules, above the spiracles overlaid with ferruginous, with a broken middorsal and a pair of supraspiracular lines pale; also a broken pale band below the spiracles. Head shield pale brownish gray, with the fuscous marking in the form of flecks. Cervical and anal shields pale brownish with many fuscous flecks. Setigerous tubercles pale fuscous, I and II of about equal size, III, IV, and V smaller and of about uniform size, their setae short, stout, and capitate. Spiracles pale fuscous, tubercular. Prolegs on third and fourth abdominal segments nearly or quite without crochets.

Third instar.—Head 0.69 to 0.72 mm. broad. Body about 7 mm. long and 1 mm. broad, of about equal width throughout, set with rather coarse, isolated, rounded, strongly convex granules, and overlaid above the spiracles with ferruginous mottled with white. Head shield brown, the fuscous markings occurring in the form of flecks. Tubercle II of abdomen about twice as large as I and slightly transverse; III, IV, and V of about equal size with I, their setae but slightly capitate. Prolegs on abdominal segments 3, 4, 5, 6, and 10, those on third segment without crochets.

Fourth instar.—Head 1.4 mm. broad. Body about 10 mm. long and 2.5 mm. broad, of about equal width throughout, skin set rather closely with isolated, strongly convex, fuscous granules as in the mature larva, all above the spiracles infuscated and indefinitely mottled with white. Head shield pale brownish, overlaid with fuscous flecks which may be entirely obscured by infuscation. Tubercle II of abdomen about twice as large as tubercle I, transverse; IV and V of about the size of I; III smaller. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10.

Fifth instar.—Head 2.1 to 2.5 mm. broad. Body about 20 to 30 mm. long and 4 mm. broad, contour, color, tubercles, and skin granules practically as in the mature larva. Head shield not reticulated as in the sixth instar, but tessellated as in Euxoa.

Sixth instar (pl. 7, C, K).—Head 3.2 to 3.5 mm. broad. Body about 30 to 45 mm. long and 7 mm. broad, of about uniform width throughout; skin with convex, rounded, distinctly isolated, very coarse shiny granules about one-twentieth of a millimeter broad and interspersed with smaller similar granules; practically unicolorous above the spiracles, color varying from light gray to nearly black. Ground color of head shield pale brownish overlaid with fuscous arcs and reticulation as in Feltia (fig. 4, B). The adfrontal sutures reach the occipital foramen. Spiracles black. Setigerous tubercles large, II distinctly three times as large as I and distinctly transverse, III slightly smaller than I. Basal portion of leg claw broadly rounded without a trace of a tooth (fig. 7, A). Each anterior proleg with about 16 to 21 crochets.

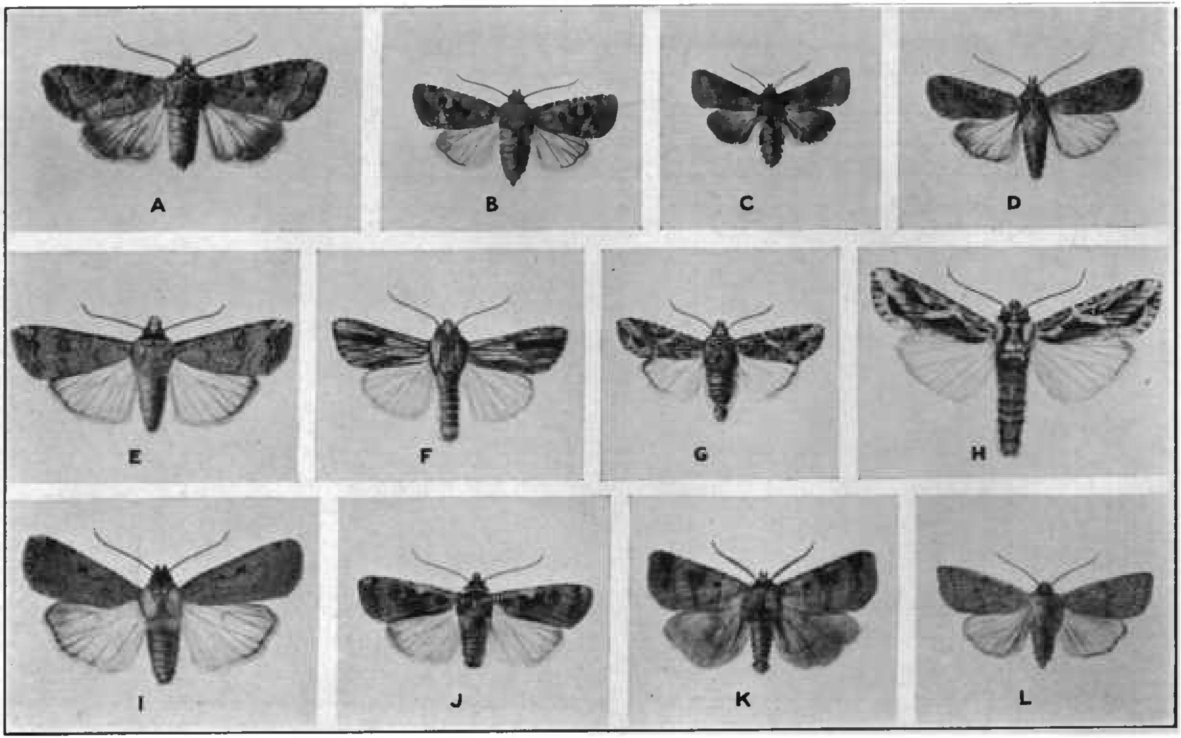
Mouth parts: Mandibles of the ordinary type. Hypopharynx (fig. 12, B) oval, broadest posteriorly, the lingua occupying somewhat less than half the length of the part and clothed sparsely medially with small spines in irregular transverse rows, the spines heavier laterally, especially in the premaxillulary area, maxillulae clothed throughout with heavy, moderately long spines, the gorge nearly bare excepting anteriorly, blade of maxillulae with about 30 coarse, broad, flat, contiguous teeth. Spinneret broad and short with a median apical notch. Labial palpi with the segments in the proportion of 11, 1, and 4, the papilla on the basal segment about equaling the second segment in length.

Setae and punctures of head: A^2 nearly twice as near to A^1 as to P^a. A^a distinctly nearer to A^2 than to A^3. P^1 slightly below the level of Adf^2. L^1 slightly nearer to L^a than to 0^2. SO^3 distinctly nearer to G^1 than to 0^3. G^1 rather variable but usually approximately equidistant from 0^3 and SO^3 or nearer to SO^3.

Arrangement of setae and punctures otherwise as in *Feltia annexa.*

PUPA

Pupa (fig. 19, C) about 17 to 22 mm. long and 5 to 6 mm. broad, maxillary palpi visible at outer angle of eye, labrum apically emarginate, prespiracular callus absent on prothorax, punctures on movably linked abdominal segments elongate, spiracles broad, directed laterally, cremaster without accessory spinules, rugulose anterior to and below the long, polished, divergent spines, which are each set on an enlarged dull base.



ADULTS OF TOBACCO CUTWORMS

A, *Polia legitima;* B, *P. renigera;* C, *P. meditata;* D, *Lycophotia saucia;* E, *L. infecta;* F, *Prodenia eridania;* G, *P. ornithogalli;* H, *P. dolichos;* I, *Agrotis unicolor;* J, *A. c-nigrum;* K, *A. badinodis;* L, *Parastichtis bicolorago.* × 0.83.

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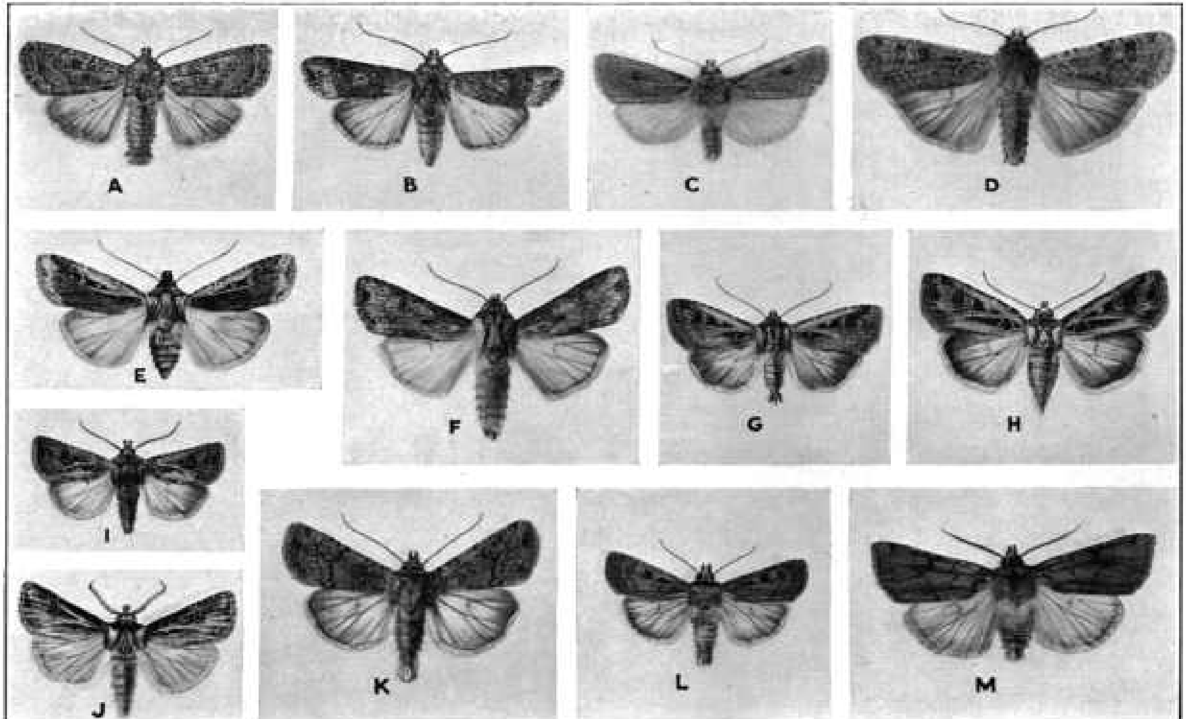


ADULTS OF TOBACCO CUTWORMS

A, *Sidemia devastator;* B, *Agrotis ypsilon;* C, *Porosagrotis vetusta;* D, *Chorizagrotis auxiliaris;* E, *Feltia annexa;* F, *F. malefida;* G, *F. subgothica;* H, *F. ducens;* I, *F. gladiaria;* J, *F. venerabilis;* K, *Euxoa messoria;* L, *E. tessellata;* M, *E. bostoniensis.* $\times$ 0.83.

LIFE HISTORY

TABLE 9.—*Length of generations in Agrotis ypsilon*

Egg stage				Larval stage			Pupal stage				
Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
1914	1914	*Days*	° *F.*	1914	*Days*	° *F.*	1914	*Days*	° *F.*	*Days*	° *F.*
July 4	July 7	3	80.0	July 27	20	84.2	Aug. 8	12	80.5	35	82.6
June 30	July 3	3	80.3	---do-----	24	83.5	---do-----	12	80.5	39	82.3
July 1	July 5[1]	3½	77.8	July 26	21½	83.7	---do-----	13	81.2	38	82.0
4	July 7	3	80.0	July 28	21	84.3	Aug. 9	12	79.2	36	82.2
4	---do-----	3	80.0	July 27	20	84.2	---do----	13	80.1	36	82.4
June 30	July 3	3	80.3	July 28[2]	25	83.5	---do----	12	79.3	40	82.0
30	---do----	3	80.3	July 27	24	83.5	---do----	13	80.1	40	82.2
30	---do----	3	80.3	July 28	25	83.5	---do----	12	79.3	40	82.0
July 4	July 7	3	80.0	July 28[3]	21	84.3	Aug. 10	13	79.4	37	82.2
4	---do----	3	80.0	---do-----	20	84.3	---do-----	13	79.4	37	82.2
4	---do----	3	80.0	---do----	21	84.3	---do----	13	79.4	37	82.2
4	---do----	3	80.0	July 31	24	83.4	Aug. 12	12	80.1	39	82.1
4	---do----	3	80.0	July 30	23	83.7	Aug. 13	14	79.7	40	82.0
4	---do----	3	80.0	July 31[3]	24	83.4	Aug. 14	14	80.0	41	82.0
4	---do----	3	80.0	Aug. 2	26	83.4	Aug. 16	14	78.7	43	81.6
25	July 28	3	88.3	Aug. 27	30	80.0	Sept. 13	17	73.7	50	78.4
Aug. 15	Aug. 18	3	79.2	Sept. 13	26	76.9	Oct. 2	19	69.3	48	74.0
18	Aug. 21	3	84.0	Sept. 14	24	75.9	---do----	18	69.1	45	73.8
18	---do----	3	84.0	Sept. 15	25	75.7	Oct. 3	18	68.9	46	73.6
15	Aug. 18	3	79.2	Sept. 17[3]	30	76.2	Oct. 6	19	68.4	52	73.5
15	---do----	3	79.2	---do----	30	76.2	Oct. 7	20	68.7	53	73.5
15	---do----	3	79.2	Sept. 18	31	76.2	---do----	19	68.6	53	73.6
18	Aug. 21	3	84.0	Sept. 17[3]	27	75.3	---do----	20	68.7	50	73.2
15	Aug. 18	3	79.2	Sept. 20	33	76.3	Oct. 9	19	68.0	55	73.6
15	---do----	3	79.2	---do.[3]---	33	76.3	Oct. 10	20	68.3	56	73.6
15	---do----	3	79.2	Sept. 21[3]	34	76.3	Oct. 14	23	66.5	60	72.7
1917	1917			1917			1917				
Aug. 20	Aug. 25	5	72.5	Sept. 26	32	69.2	Nov. 5	40	53.5	77	61.3
20	---do----	5	72.5	---do----	32	69.2	Nov. 6	41	53.5	78	61.2
19	Aug. 22	3	73.7	Sept. 16	25	70.3	Nov. 15	60	54.9	88	59.9
19	---do----	3	73.7	Sept. 20	29	70.2	Nov. 17	58	54.3	90	60.1
20	Aug. 25	5	72.5	Oct. 3[2]	39	67.9	Nov. 25	53	50.7	97	58.7
20	---do----	5	72.5	Oct. 2	38	68.0	Nov. 27	56	50.5	99	58.3
20	---do----	5	72.5	Oct. 3	39	67.9	Nov. 28	56	50.3	100	58.3

[1] Noon. [2] 3 individuals. [3] 2 individuals.

PREOVIPOSITION PERIOD

One moth emerged on the night of June 19, 1914, and moths continued to emerge in the cage until June 25, the main emergence occurring June 21 to 22. Oviposition began on the night of June 30, 9 days after the first pair appeared and 11 days after the first moth emerged, and continued until July 8, 13 days after the last moth had emerged. Throughout the season of 1914 a similar period was found to elapse between emergence and oviposition. In 1915 one moth emerged on the night of July 29 and another on the night of July 31 and fertile eggs were deposited on the night of August 5, 5 to 7 days after emergence.

EGG STAGE

TABLE 10.—*Duration of egg stage in Agrotis ypsilon*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
June 30, 1914	July 3, 1914	3	80.3	Aug. 22, 1917	Aug. 27, 1917	5	81.4
July 1, 1914	July 5, 1914	3.5	77.8	Aug. 24, 1917	Aug. 29, 1917	5	76.3
July 2, 1914	July 6, 1914[1]	3.5	78.5	Aug. 27, 1917	Sept. 1, 1917	5	75.2
July 3, 1914	July 6, 1914	3	79.5	Oct. 6, 1916	Oct. 12, 1916	6	70.3
July 4, 1914	July 7, 1914[2]	3	80.1	Oct. 31, 1915	Nov. 8, 1915	8	60.6
July 5, 1914	July 8, 1914	3	82.5	Oct. 25, 1914	Nov. 10, 1914[2]	16	54.4
Aug. 5, 1915	Aug. 8, 1915	3	77.8	Nov. 3, 1915	Nov. 11, 1915	8	55.8
Aug. 7, 1915	Aug. 11, 1915	4	78.5	Nov. 4, 1915	Nov. 12, 1915	8	63.9
Aug. 15, 1914	Aug. 18, 1914	3	79.2	Oct. 29, 1914	Nov. 12, 1914	14	56.0
Aug. 17, 1914	Aug. 20, 1914	3	84.2	Oct. 31, 1914	Nov. 13, 1914	13	56.7
Aug. 19, 1917	Aug. 22, 1917	3	82.0	Nov. 4, 1915	Nov. 14, 1915[2]	10	59.7

[1] Noon. [2] 2 individuals.

LARVAL STAGE

As shown in Table 9, the larval stage varies in duration from 3 weeks or slightly more in July to over 4 weeks the latter part of September. In July, 1914, the time spent in the various instars was about as follows: First instar, 2 days; second instar, 2 days; third instar, 3 days; fourth instar, 4 days; fifth instar, 4 days; and sixth instar, 5 days.

PUPAL STAGE

In addition to those given in Table 9, the pupal stages given in Table 11 have been recorded.

TABLE 11.—*Duration of pupal stage in Agrotis ypsilon*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
June 8, 1914	June 21, 1914	13	82.0	July 10, 1915	July 23, 1915	13	81.3
June 9, 1914	do	12	81.7	July 16, 1915	July 28, 1915	12	78.4
June 10, 1914	June 22, 1914	12	81.8	Do	July 29, 1915	13	78.7
June 6, 1914	June 19, 1914	13	82.0	July 18, 1915	July 31, 1915	13	78.9
June 8, 1914	June 22, 1914	14	82.4	Sept. 20, 1916	Oct. 12, 1916	22	62.8
June 11, 1914	June 23, 1914	12	81.9	Oct. 6, 1914	Nov. 5, 1914	30	58.6
June 8, 1914	June 24, 1914	16	83.0	Do	Nov. 6, 1914	31	58.7
June 11, 1914	June 25, 1914	14	82.8	Oct. 7, 1914	Nov. 8, 1914	32	58.3
June 18, 1916	July 3, 1916	15	75.7	Do	Nov. 12, 1914	36	57.3
July 11, 1915	July 23, 1915	12	81.0				

The July-August pupal stage requires about 2 weeks or somewhat more. The August-September pupal stage requires about 3 weeks for the earlier individals; for the later ones the pupal stage is much prolonged, requiring in some cases as much as 8 or 9 weeks for its completion. Breeding work covering several seasons indicates that October 7 is about the earliest date of pupation which results in overwintering pupae, those pupae which are formed prior to this date producing moths the same season.

Parasites and Predators

Larvae of *Bonnettia compta* Fall. emerged from larvae of *Agrotis ypsilon* and formed puparia August 24 and the flies emerged September 13, 1917. *Ophion bilineatum* Say and *Meteorus vulgaris* Cress. are also parasitic on larvae. Lampyrid larvae, larvae of the elaterid *Cebrio bicolor* Fab., *Formica fusca* L., and the spider *Phidippus audax* Hentz have been noted to be predatory on larvae. A species of Mermis has been obtained as a parasite of larvae.

Coquillett (*19*) records the breeding of *Zenillia eudryae* Town., *Bonnettia compta* Fall., *Tachinomyia robusta* Town., and *Frontina archippivora* Will. from this species. Coquillett also records (*18*) that an adult of *Hister sexstriatus* Lec. attacked and killed a nearly mature larva. Muesebeck (*50*) records *Meteorus vulgaris* Cress. as a parasite. Sanderson (*55*) records rearing *Gonia capitata* DeG. from pupae. Aldrich and Webber (*2*) include this species among the hosts of *Zenillia formosa* A. and W. and *Madremyia saundersii* Will.

THE DINGY CUTWORM, FELTIA DUCENS WLK. AND FELTIA SUBGOTHICA HAW.

Distribution

Feltia ducens is a northern species occurring throughout the extent of the United States east and west and in Canada, with the line of recorded southern distribution including Virginia, Tennessee, Missouri, Kansas, Colorado, and Utah. It is one of the most common cutworms at Clarksville, Tenn., and South Boston, Va., and probably occurs considerably farther south, but larvae have not been included in numerous sendings from Texas, Louisiana, and Florida.

Moths of this species have been reared from larvae from Geddes, S. Dak., Sioux City, Iowa, Clarksville, Tenn., Hixson, Tenn., and South Boston, Va.

The distribution of *Feltia subgothica*, including the variety *herilis*, is much the same as that of *F. ducens*, but the recorded range includes Texas and New Mexico. It has also been reported as injurious in Chile.

Food Plants

The observed food plants include *Aster ericoides*, bean, bluegrass, cabbage, celery, chickweed, clover, corn, buds of fruit trees, goldenrod, lettuce, melon, mullein, pea, plantain, potato, *Rumex crispus*, rye, strawberry. sweet potato, tobacco, tomato, turnip, and wheat.

Food Habits and Larval Habits

Owing to uncertainty due to the fact that the writer is not able to distinguish between the larvae of *Feltia ducens* and *F. subgothica*, they are frequently referred to as *ducens-subgothica* in these pages. Larvae of these species are remarkably hardy. Under conditions of drought or moisture they thrive in breeding apparatus where most other species would not be able to survive. Several specimens were overlooked in a graniteware pan containing nothing but a little dry earth for a little over a month, but at the end of that time they were still alive and capable of continuing their development. Species having such resistance have nothing to fear under the conditions occurring when fields are plowed.

In these species the larvae pass a long, inactive period in the soil during the summer. Before the larva enters this state an irregular, roughly plastered cell is made, usually within one-fourth inch of the surface of the soil, into which the larva retires. Here it contracts somewhat, and continues life without food, although still capable of repairing damage to the cell and quite active when removed from its retreat. Frequently these cells are built with an exit hole to the surface, and larvae sometimes emerge and crawl about during their period of aestivation. After about three months spent thus in the soil, the larvae are nearly as plump as in the beginning.

The larvae occur in greatest numbers in situations which provide suitable conditions for the development of a winter growth of wild plants, provided there is also a suitable cover in the nature of weed litter, clover stems, or fallen grass. In these situations they prefer to lie among the rubbish basking in the sunshine, or burying themselves shallowly in the soil. They are especially prone on warm spring days to extend themselves along the lower surface of bits of wood, boards, or loose stones where they may get the benefit of the heat absorbed by these. Old weedy clover fields which provide proper cover usually are heavily infested, and in such places they are among the more common cutworms in Tennessee and Virginia. They are also a common source of injury in gardens and sometimes become a serious pest in meadows and wheat fields. Forbes (*28*) has found this to be one of the commonest species in cornfields in Illinois. Slingerland (*58*) found that some larvae of this species ascended peach trees to feed upon the buds, but states that the climbing habit is only slightly developed. Webster (*79*) gives an account of injury to ripe strawberries.

Seasonal History and Importance

Owing to the impossibility of distinguishing with certainty between the larvae of these two species, and a like uncertainty in some cases with adults taken somewhat battered in traps, it is more satisfactory to give a composite seasonal history, with some subsidiary notice of each of the species.

The larvae of *Feltia ducens* apparently begin to go into aestivation earlier than the larvae of *F. subgothica*. This is shown by the fact that from 100 larvae ready to enter aestivation April 23, 1918, 38 moths were obtained, all of which were of the *ducens* type, while from 100 larvae from the same locality which were ready to enter aestivation May 22, 1918, 30 moths were obtained of which 20 were of the *subgothica* type. There was a slight corresponding difference in the period of emergence of the adults, although the record from moths taken in bait traps in 1917 and 1918 gave evidence just the reverse of the above, the moths of *ducens* continuing in flight slightly longer in each season than did the moths of *subgothica*. The breeding record, however, probably represents the true condition with regard to entrance into aestivation.

These are one-brooded species. The winter is passed by the larvae in the third and fourth instars. These begin to become mature and enter aestivation the last of March, and most of them have entered their inactive summer stage by the middle of May, although stragglers will be found feeding even as late as the latter part of July. These larvae begin pupating early in August, the period of maximum pupation extending from about the middle of August to about the end of the first week in September. Moths begin emerging in small numbers about the middle of August and continue to emerge until the last of October, occasional stragglers extending the period to the latter part of November. The period of maximum emergence both for reared and trapped moths has been between September 10 and October 10. These moths lay eggs which produce the overwintering larvae. In 1918, 1,029 moths of *ducens* and 137 moths of *subgothica* were taken, and previous trappings have given similar results.

FELTIA DUCENS

This is also one of the most common cutworms in the more northern States as recorded by Gillette (*34*) in Iowa, Forbes (*28*) in Illinois, Slingerland (*58*) in New York, and Gibson (*33*) in Canada. One very remarkable feature of its seasonal history is that in all the above localities the main emergence of moths occurs between August 15 and September 5 while the principal flight in northern Tennessee begins about September 10 and ends about October 10, about a month later than the northern flight. And this in spite of the fact that most of the larvae in northern Tennessee have entered the soil by the middle of May, and it is the middle of June in Illinois and the last of June in Canada before the greater portion of the larvae in these localities have disappeared. Thus the larvae in Illinois and Canada finish their activities a month or six weeks later than is the case in Tennessee and yet the moths emerge in the North a month earlier than in the South. The reason for this is discussed under "Distribution."

FELTIA SUBGOTHICA

Some possible differences between the seasonal history of this species and that of *ducens* are noted above, but the two species are closely parallel in the main features of the seasonal apportionment of their activities. Slingerland found that the moths were on the wing over practically the same period as those of *ducens*, and that 70 per cent of the moths of *subgothica* were taken between August 6 and 19. All reports indicate that the main flight occurs in the North during August and the early part of September.

Slingerland (*57*) in 1893 took 2,382 moths of *ducens* in traps and but 31 specimens of *subgothica;* at Clarksville, in 1918, 1,029 moths of *ducens* were taken and but 137 specimens of *subgothica;* Smith (*61*) found *subgothica* less abundant than *ducens* in New Jersey, and states that it is entirely wanting in some localities; and Snow (*64*) in Kansas considers *ducens* to be the more abundant of the two species. Evidently *subgothica* is generally less common than *ducens*, and yet the species is not uncommon over a wide range and was found by Webster (*80*) to be the most common and pernicious species in Indiana cornfields in 1889 as it was also in Illinois in 1887.

Description of Stages of Feltia ducens

ADULT

In *Feltia ducens* (pl. 4, H) the orbicular spot is V-shaped, confluent and concolorous with the pale submarginal coloration of the costa, and brought into strong contrast by a black posterior and lateral border which also connects the orbicular broadly with the reniform spot. The moth rather closely resembles *F. subgothica*. In *ducens* the ground color of the forewings is gray; in *subgothica* the gray is tinged with brownish. In *ducens* only the outer margin of the hind wing is dusky, while in *subgothica* the entire wing tends to be infuscated. The median vein in *ducens* is much more prominently pale than is the case with *subgothica*, and veins 3 and 4 in *ducens* are also more distinctly margined with pale, and this color invades the dark terminal space along these veins much more distinctly than is the case with *subgothica*. Expanse from slightly less than to slightly more than 1½ inches.

EGG

The egg is whitish, oblong-oval in outline, flattish in profile, 0.66 mm. long, 0.5 mm. broad, and 0.38 mm. high, with about 36 sinuate ribs and no transverse lines. The second day after deposition the upper half of the egg becomes more or less brownish. It is not distinguishable from the egg of *F. subgothica*.

LARVA

In *F. ducens* the adfrontal sutures terminate in the occipital sinus; the head shield bears reticulate markings (fig. 4, B); the skin granules are coarse, isolated, and strongly convex; and tubercle II is of practically the same size as tubercle I. This combination of characters will serve to positively distinguish this species from all others with the exception of *F. subgothica*.

The writer is unable to distinguish positively between this larva and that of *F. subgothica*, although much work has been done with this in view, including a very careful comparison of live bred specimens of the two species. In *ducens* the dorsum is more often ferruginous while in *subgothica* it is more usually gray, but the bred larvae are duplicates in this respect and extensive breeding of carefully selected series of larvae of a certain color has resulted in the obtaining of both species in nearly every case. The coarser, more flattened skin granules are usually more numerous in larvae of *subgothica*, and this is the nearest approach to a definite distinctive character, but larvae of *ducens* will be found in which these granules are equally numerous. The larvae of *subgothica* probably average somewhat larger than those of *ducens*, as indicated in the photographs (pl. 6, A, B), but the writer has no definite proof of this.

The larval descriptions given under *F. subgothica* will apply equally well to this species.

PUPA

The pupa of this species (fig. 19, B) is not distinguishable from that of *F. subgothica*.

Description of Stages of Feltia subgothica

ADULT

In *F. subgothica* (pl. 4, C) the orbicular spot is V-shaped, confluent and concolorous with the brownish submarginal coloration of the costa and margined laterally and posteriorly with black, which also connects the orbicular broadly with the reniform spot. The differences between this species and the closely related *F. ducens* are discussed under the latter species. Expanse about 1½ inches or slightly more.

In breeding cages the writer has found pairs of opposite species in copula when active, strong males of the proper species were present, but eggs have been obtained from such matings in only one case and these were infertile.

From eggs obtained from a moth officially determined as *F. ducens* a single moth was bred which was officially determined as *F. subgothica*. The writer had direct charge of these breeding experiments, which were very carefully conducted, but would hesitate to say positively that a moth of the one species was bred from the egg of the other.

EGG

The egg is oblong-oval in outline, somewhat flattened in profile, 0.60 to 0.65 mm. long, 0.50 mm. broad, and 0.36 mm. high, with about 56 distinctly sinuate ribs and no transverse lines, a small area about the micropyle and the entire base reticulate. On about the second day after deposition the egg becomes faintly brownish above, and, before hatching, it becomes gray.

A caged moth in ovipositing kept the horny ovipositor extruded and pressed it firmly against objects, apparently indicating that the eggs are normally forced into positon as might be the case were they deposited in crannies or beneath the leaf sheaths of grasses. A dissected moth contained about 400 eggs, 116 of which were nearly mature.

LARVA

This larva belongs to the class in which the adfrontal sutures terminate in the occipital foramen and has the fuscous markings of the head shield disposed in a reticulate pattern, while tubercle II of the abdomen is scarcely, if at all, larger than tubercle I, and the skin granules are large, strongly convex, and distinctly isolated. These characters will serve to identify this species with great certainty from all species with the exception of *F. ducens*. These two larvae are evidently very closely related.

First instar.—Head 0.31 mm. broad. Body about 3 mm. long and 0.48 mm. broad, broadest through about the first four abdominal segments; skin set closely, especially on the dorsum, with small granules; general color dirty gray, middorsal line and pair of ill-defined, sinuous, supraspiracular lines white, the supraspiracular area mottled with brownish and ferruginous. Cervical and anal shields fuscous brown, not distinctive. Head shield uniform dark fuscous. Setigerous tubercles fuscous, of about equal size, their setae about the length of an abdominal segment and moderately capitate. Legs dark fuscous. Functional prolegs on abdominal segments 5, 6, and 10. Spiracles protuberant, subcylindrical.

Second instar.—Head 0.52 mm. broad. Body about 5 to 5.5 mm. long; skin distinctly granulose; general color rather dark fuscous, dorsal area infuscated ferruginous, with a median pale line, subdorsally a sinuous pale line consisting of a series of distinct, yellowish-white, oblique dashes, supraspiracular area fuscous tinged with ferruginous, the subspiracular stripe pale with a ferruginous center, venter flecked with ferruginous. Setae strongly capitate.

Third instar.—Head 0.65 to 0.77 mm. broad. Body about 5 to 8.6 mm. long; skin densely granulose; general color of body light gray, dorsal area conspicuous gray marked with ferruginous and fuscous, a middorsal pale line demarked with fuscous and a segmental series of indistinct, fuscous, rhomboidal figures which may be reduced to a series of fuscous V-shaped marks opening posteriorly and including setigerous tubercles I and II in the arms; supraspiracular area very dark fuscous flecked with white, with the usual pair of indistinct, pale submedian lines, the subspiracular band narrow, grayish with a ferruginous or brownish center, venter pale fuscous irrorate with whitish. Head shield black. Cervical and anal shields concolorous with the adjacent parts. Setigerous tubercles large, prominent, dark fuscous, I and II of equal size, their setae short, very dark and strongly capitate. Legs pale fuscous. Prolegs functional on abdominal segments 4, 5, 6, and 10.

Fourth instar.—Head 1.2 mm. broad. Body about 12 mm. long and 2 mm. broad; tapering slightly posteriorly; skin granules as in the mature larva; coloration as in the fifth instar. Head shield ground color white, overlaid with black dorsally, the reticulation visible laterally. Setigerous tubercles I, II, and III of the abdomen of about equal size, IV and V larger, all fuscous.

Fifth instar.—Head 1.7 to 2 mm. broad. Body about 18 to 23 mm. long and 4 mm. broad; tapering gently posteriorly; skin set with coarse, narrowly isolated, convex granules interspersed irregularly with secondary granules as in the mature larva; coloration much as in the mature larva, the supraspiracular area more nearly uniform fuscous throughout, and the white subspiracular band more distinct than usual in the mature larva, much flecked with white ventrally. Head shield ground color pale grayish with heavy dark-fuscous submedian arcs, a fuscous area in the ocellar region, and fuscous reticulation. Setigerous tubercles I, II, and III of the abdomen of about equal size, IV and V larger, all fuscous.

Sixth instar (pl. 6, B).—Head 2.5 to 2.7 mm. broad. Body about 22 to 32 mm. long and 5.5 mm. broad; of nearly equal width throughout but tapering slightly posteriorly, posterior extremity rather blunt; skin set with coarse, isolated, shining, roundingly subconical, chitinous granules which are nearly round or transversely elongated in outline (fig. 3, E); general color pale grayish brown, sometimes tinged with ferruginous, pale middorsal line demarked with fuscous particularly at the juncture of the segments; setigerous tubercles I and II of abdomen narrowly, obscurely connected by infuscation, the area between these four tubercles sometimes wholly infuscated forming a series of more or less definite ovoid or rhomboidal dorsal figures, their apices formed by the median infuscation at the juncture of the segments; supraspiracular area fuscous, speckled with white, darker subdorsally where it forms definite dark-fuscous spots on at least the anterior half of each abdominal segment; below the spiracles a band of white flecks, venter more or less flecked with white. Head shield ground color very pale brownish gray, the submedian arcs strong, dark fuscous, a fuscous area in the ocellar region, the reticulation fuscous and ferruginous and disposed as shown in Figure 4, B, sometimes partially obsolete, the adfrontal sutures terminating in the occipital foramen. Cervical and anal shields not distinctive. Tubercle II of the abdomen of practically the same size as tubercle I, III slightly smaller than I, IV and V distinctly larger and of about equal size. Spiracles black. Prolegs pale, each anterior proleg with about 4 to 12 crochets. Legs pale, the basal portion of the claw often without a trace of angulation.

Mouth parts: Mandibles of the ordinary type. Hypopharynx as in *Agrotis ypsilon*, the lingua occupying about one-third the length of the part, blade of maxillulae with about 15 to 20 slightly isolated, rather small, flat, acutely triangular teeth. Spinneret broad and short with a median apical notch. Labial palpi with the segments in the proportion of 27, 3, and 7.

Setae and punctures of head: Punctures F^a very slightly below the level of setae F^1. SO^3 distinctly nearer to G^1 than to O^3. G^a somewhat nearer to O^3 than to G^1. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 18 mm. long and 6 mm. broad, maxillary palpi not visible, labrum emarginate, prespiracular callus present on prothorax, about three rows of coarse, round punctures near anterior margin of movably linked abdominal segments, spiracles broad, directed laterally, cremaster without accessory spinules, spines long, stout, polished, convergent, nearly approximate at base, the basal enlargement very distinct, a minute roughened area before the bases of the spines and a larger one below, otherwise smooth.

The pupal cell is usually transversely flattened and is more or less crooked and irregular and roughly plastered within. Of about 50 cells examined all were within about one-fourth inch of the surface of the soil and a considerable number were provided with an opening to the surface.

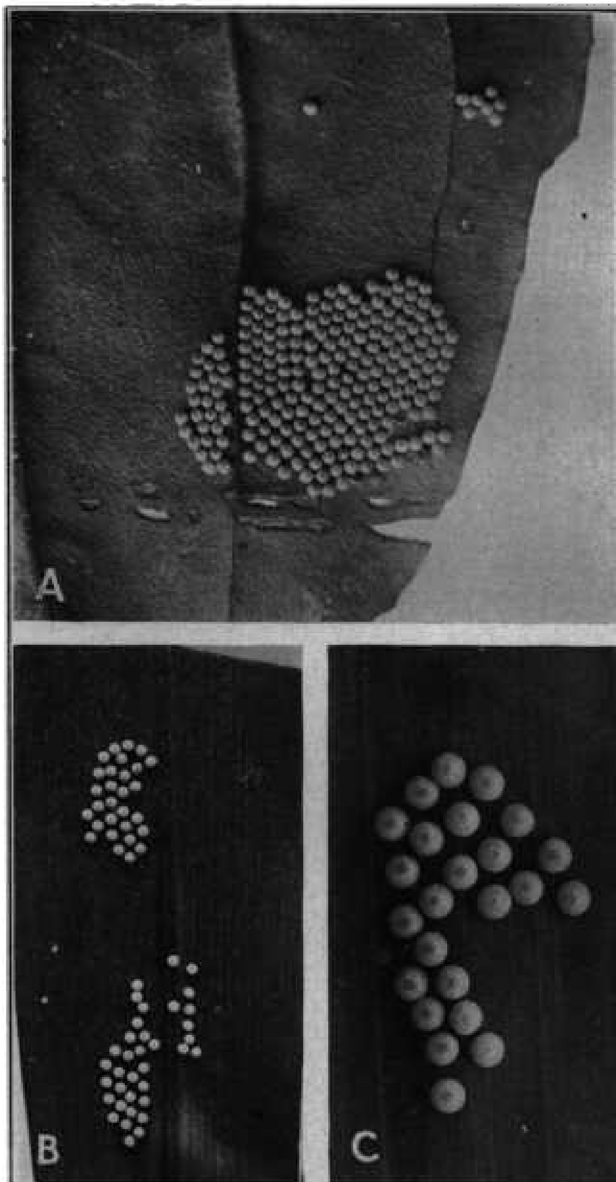
Life History of Feltia ducens

EGG STAGE

Table 12.—*Duration of egg stage in Feltia ducens*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	°*F.*
Sept. 11, 1911	Sept. 17, 1911	6	80.7
Sept. 15, 1918	Sept. 29, 1918	14	61.5
Oct. 11, 1918	Oct. 22, 1918	11	63.7
Oct. 7, 1917	Oct. 28, 1917	21	53.7

64a



EGGS OF TOBACCO CUTWORMS

A, Egg mass of *Lycophotia saucia*, × 3; B, egg mass of *L. infecta*, × 3; C, eggs of *L. infecta*, × 9.

LARVAL STAGE

Larvae which hatched September 16, 1911, were in the last instar March 22, 1912, and four or five additional months were spent in the aestivating stage, giving a total larval period of 10 or 11 months.

PUPAL STAGE

TABLE 13.—*Duration of pupal stage in Feltia ducens*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Sept. 3, 1918	Oct. 3, 1918	30	65.3	Sept. 18, 1917	Oct. 22, 1917	34	59.6
Sept. 16, 1917	Oct. 18, 1917	32	61.5	Sept. 16, 1917	Oct. 26, 1917	40	57.4
Sept. 17, 1917	Oct. 20, 1917	33	60.5	Sept. 25, 1917	Nov. 24, 1917	60	52.5

The records in Table 13 indicate that the pupal stage in this species is decidedly longer than that of *F. subgothica*, but these pupae were kept under conditions somewhat less closely approximating normal than was the case with the pupae of *F. subgothica*, and it is probable that, in nature, the pupal stages of the two species are of nearly or quite the same duration.

LIFE HISTORY OF FELTIA SUBGOTHICA

PREOVIPOSITION PERIOD

Moths which emerged on the night of September 8, 1912, deposited fertile eggs on the night of September 10, two days after emergence.

EGG STAGE

TABLE 14.—*Duration of the egg stage in Feltia subgothica*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Sept. 6, 1915	Sept. 12, 1915	6	80.4	Oct. 2, 1918	Oct. 12, 1918	10	68.6
Sept. 7, 1915	Sept. 13, 1915	6	81.1	Oct. 2, 1916	Oct. 13, 1916	11	64.5
Sept. 10, 1912	Sept. 15, 1912	5	82.3	Oct. 4, 1916	Oct. 14, 1916	10	64.7
Sept. 12, 1911	Sept. 18, 1911	6	80.2	Oct. 4, 1918	Oct. 15, 1918	11	67.4
Sept. 20, 1910	Sept. 28, 1910	8	69.1	Oct. 6, 1918	do	9	65.7
Sept. 19, 1914	Sept. 29, 1914	10	67.2	Oct. 7, 1918	Oct. 19, 1918	12	64.7
Sept. 15, 1918	Sept. 30, 1918	15	61.7	Oct. 12, 1915	Oct. 24, 1915	12	64.7
Sept. 17, 1918	Oct. 4, 1918	17	62.9	Oct. 14, 1915	Oct. 25, 1915	11	64.4
Sept. 25, 1918	Oct. 6, 1918	11	67.2				

LARVAL STAGE

Larvae which hatched September 29, 1910, were in the last instar March 28, 1911. The aestivating stage is assumed during an additional four or five months, so that, in all, 10 or 11 months are spent in the larval stage.

PUPAL STAGE

TABLE 15.—*Duration of pupal stage in Feltia subgothica*

Pupated night of—	Number emerged	Emerged night of—	Pupal stage	Average mean temperature
			Days	° *F.*
Aug. 10, 1916	1	Sept. 2, 1916	23	76.0
Aug. 18, 1919	3	Sept. 5, 1919	18	73.2
Aug. 22, 1919	1	Sept. 10, 1919	19	73.8
Do	6	Sept. 12, 1919	21	73.8
Do	1	Sept. 14, 1919	23	73.6
Aug. 25, 1919	3	do	20	73.2
Aug. 28, 1910	1	Sept. 15, 1910	18	73.6
Aug. 25, 1919	7	Sept. 15, 1919	21	73.3
Aug. 30, 1919	3	do	16	73.7
Aug. 25, 1919	1	Sept. 16, 1919	22	73.4
Aug. 30, 1919	3	do	17	73.8
Do	2	Sept. 17, 1919	18	73.7
Sept. 3, 1919	1	Sept. 18, 1919	15	75.9
Aug. 22, 1919	1	do	27	74.0
Aug. 30, 1919	4	do	19	74.0
Sept. 1, 1919	4	Sept. 19, 1919	18	75.0
Sept. 3, 1919	4	Sept. 21, 1919	18	76.4
Sept. 2, 1916	1	Sept. 21, 1916	19	69.7
Do	1	Sept. 27, 1916	25	68.7
Sept. 9, 1916	1	do	18	65.5
Sept. 5, 1917	1	Oct. 2, 1917	27	66.8

PARASITES AND PREDATORS

Two hundred and one larvae of *F. ducens* and *F. subgothica*, collected in the spring of 1919 and reared, showed 26.3 per cent parasitism by the following species and in the proportions indicated:

Microplitis feltiae Mues	29 larvae.
Berecyntus sp	4 larvae.
Gonia frontosa Say	16 pupae.
Paranomalon propinquum Cress	4 pupae.

The period of activity of the above parasites is in the spring, as indicated by the following records (the April and May collections being made from the same spot):

Of 116 larvae collected in the winter, none was parasitized.
Of 101 larvae collected April 19, 1919, 18 were parasitized.
Of 100 larvae collected May 24, 1919, 35 were parasitized.

The above 201 larvae produced 60 moths, leaving 88 larvae which died from causes unassignable, some, apparently, from disease. The 101 larvae collected April 19, 1919, produced 46 of the 60 moths. It may be that the much higher percentage of parasitism of the May larvae over those collected in April is not so much due to their longer exposure to parasitic attack as to a tendency among the parasitized and weaker larvae to delay entrance into aestivation.

In connection with the following notes concerning the above parasites, it should be noted that after the larvae were collected on the dates shown they were kept in tight tin boxes. The period of development is rather extended in all these parasites.

Micropolitis feltiae Mues. began emerging from its hosts about September 9 and continued to emerge until September 29. The period spent in the cocoon was about 12 days. The parasite, after emerging from the host, spins an unattached cocoon much like that of Apanteles, and but one parasite occurs in each Feltia larva. These host larvae are conspicuouslly smaller than normal, being about 16 to 18 mm. long and 4 mm. broad, and continue active in some cases for weeks after the emergence of the parasite.

A Berecyntus species, which occurred to the number of several hundred in each of the larvae attacked, began killing host larvae about August 18, 1919, and continued to do so until August 22. The period from the death of the host to the emergence of the parasite was about 30 days.

Larvae parasitized by *Gonia frontosa* Say finish their growth and pupate, and the puparium of the fly is formed within the pupal shell of the host, becoming noticeable about the middle of September. The flies emerge the following season from early in March to at least the latter part of March.

The host larvae of *Paranomalon propinquum* Cress. also complete their growth and pupate, and the parasite spins its cocoon within the pupal shell of the host, emerging the following spring.

In 1921, 198 larvae were collected when nearly mature and reared singly in tin boxes with unsterilized field earth. The mortality was as follows:

Moths emerged		39
Parasitized		48
Insects:		
Ophion sp	10 larvae.	
Microplitis feltiae Mues	4 larvae.	
Amblyteles suturalis (Say)	1 pupa.	
Gonia frontosa Say	8 pupae.	
Nematodes:		
Mermis sp	3 larvae.	
Disease:		
Metarrhizium anisopliae	6 larvae.	
Beauveria sp	10 larvae.	
Botrytis rileyi Farl	1 larva.	
Penicillium (*briardi* Vuill. ?)	2 larvae.	
Polyhedral disease (?)	2 larvae.	
Bacterial disease (?)	1 larva.	
Died as larvae without apparent cause		106
Died as pupae without apparent cause		4
Injured as larva		1

Apanteles griffinii Vier. was reared by J. U. Gilmore from larvae at South Boston, Va. The parasites emerged on May 4, 1918, and were confined in a glass tube with mature larvae of *ducens-subgothica* on May 8, when the parasites began to oviposit in the larvae. The parasitic larvae emerged from the host on May 22 and spun cocoons, and the adults appeared May 28, giving 20 days as the length of a generation in this species.

Specimens of *Ophion bilineatum* Say were obtained April 14, 1919, and May 5, 1919, from larvae collected May 22, 1918. *Meteorus vulgaris* Cress. has been reared from larvae. Their small elongate-oval light-brown cocoons were formed May 6, 1919, and the adults appeared May 20, several parasites occurring in each host. *Meteorus dimidiatus* Cress. and *M. autographae* Mues. have also been reared from larvae. An Apanteles species was reared from larvae. Cocoons formed May 17, 1911, were white and were concealed in a fluffy mass of very fine white silk and produced the adult May 22. Two specimens of *Rogas aciculatus* Cress. have been reared. These formed cocoons in the hardened anterior portions of two larvae on April 18, 1911, and the adults emerged May 10, giving an extra-larval period of 22 days. *Amblyteles suturalis* (Say) var. (?) was obtained from a pot cage September 2, 1911. Larvae found dead and flabby on several occasions have been found to contain nematodes (Mermis) about 8 inches long.

Cutworms seem to be a large element in the food of *Scarites subterraneus* Fab. and *S. substriatus* Hald., as they are not infrequently found near dead cutworms in the field under boards and stones. In the laboratory they have eaten about one larva per day, severing the head from the body in nearly every case. A larva was taken in the field March 16, 1920, feeding on a large tipulid larva. When placed in a pill box with cutworms this predator very shortly attacked one of the cutworms and consumed it entirely. It was determined by Böving as a species of Calosoma. Toads have been observed feeding on these species of cutworms.

A spider, probably *Xysticus nervosus* Banks, was found under a stone March 20, 1913, feeding on a fourth or fifth instar larva. The spider hung suspended by its jaws when the larva was picked up and was photographed feeding. It fed on other cutworms in confinement, and afterwards the larvae were found to consist of only shrunken, empty skins. In 30 seconds after being bitten, a fifth-instar larva of Feltia was quiet but still alive. After inflicting the bite the spider stood aside and waited until the larva had ceased threshing about before seizing it again.

Mites have been found on larvae in a few instances, but whether these were feeding on the larva or merely using it as a means of locomotion is not known.

Several larvae have died in breeding cages of a disease (Pl. 2, F) in which the venter becomes waxy white before death and the larva becomes flaccid after death. A few have also died which were filled with a pinkish powder.

Webster (*80*) records the rearing of *Anthrax hypomelas* Macq. from a pupa. Coquillett records (*19*) *Phorocera claripennis* Macq. and *Winthemia quadripustulata* Fab. Viereck (*77*) records *Meteorus dimidiatus* Cress. Muesebeck (*50*) records *Meteorus vulgaris* Cress. as a parasite.

THE CLAY-BACKED CUTWORM, FELTIA GLADIARIA MORR.

Distribution

Feltia gladiaria is catalogued as occupying the United States east of the Rocky Mountains. Norman (*51*) has found moths not infrequent at St. Catharines, Ontario. Larvae have been examined from New York, Geddes, S. Dak., Sioux City, Iowa, Manchester, Ill., South Boston, Va., Richmond, Va., Clarksville and Hixson, Tenn., Boulder, Colo., Logan, Utah, Uvalde, Tex., and Quincy, Fla.

Food Plants

The known food plants include tobacco, *Rumex crispus*, clover, corn, cabbage, aster, goldenrod, pansy, oats, grass, potato, bean, sweet potato, tomato, onion, blackberry, raspberry, hemp, and strawberry.

Habits and Importance

The larva is found in much the same situation as the larvae of *F. ducens-subgothica;* it is oftener abundant in sod or pasture land than the above species, although showing a marked preference for clover as food. It has been recorded as being particularly injurious to corn and clover and is one of the more common tobacco cutworms at Clarksville, where the larvae are a little later in reaching the aestivating stage than some of the other species and are thus present in greater relative numbers when tobacco is set out in the fields.

This cutworm has the habit, in common with several others, of making a permanent tunnel 2 to 8 inches long in the soil, with an opening near the plant attacked. The burrow becomes smooth from continued use and usually has the mouth open, though sometimes this may be plugged by a bit of leaf or by projecting portions of the food which the larva habitually drags into the burrow at night.

Although occurring over a wide range, this species has come into prominence in only two States, Illinois and Kentucky, and the metropolis of the species is apparently in this region. In 1887 and 1888 it was the most abundant and by far the most destructive species in Illinois, and larvae were nearly as abundant in 1901. Forbes (*26*, *28*) records that they invaded fields in enormous numbers by spreading regularly outward from centers of abundance in grassland and clover and played havoc with clover, corn, potatoes, and sweet potatoes in particular, although rather indiscriminate in their choice of food. It was observed that the larva seized the blades of corn by the pendant tip and consumed the plant from tip to base, and clover was also eaten from the upper branches downward. One hundred and twenty larvae were taken from about the base of a single hill of corn. A notable outbreak of this species occurred in Kentucky in the spring of 1895, in company with smaller numbers of several other species, in which the larvae disseminated from centers of infestation but "without the unanimity of purpose displayed by the army worm" (*Cirphis unipuncta* Haw.). Garman (*32*) states with regard to this outbreak that great damage was done to young clover, corn, tobacco, hemp, onions, and other garden crops. Many newly set strawberry beds were also destroyed and the larvae ate the young canes of blackberry and raspberry.

Seasonal History

This is a one-brooded species. The winter is passed in the larval stage in the first and second instars. These larvae begin to become mature in small numbers the last of March, although most are then in the third and fourth instars, and nearly all are mature by the first week in May, a few stragglers continuing the active larval stage to the latter part of May. Larvae begin to aestivate in small numbers early in April and nearly all have ceased activity by the middle of May. These larvae spend the summer in cells in the ground and begin pupating the last week in August. The main emergence occurs between October 1 and 10, but emergence continues until about the middle of October, moths being on the wing in very small numbers the latter part of October. These deposit eggs which produce the overwintering larvae.

Forbes (*26*) states that the larvae were destructive from about the middle of April to the 1st of June, all having entered the soil by the middle of June. The larvae remained quiescent for six weeks or more in some cases before pupating and moths appeared during September and October, the greater number during the latter half of September. Garman (*32*) states that larvae were destructive from the latter part of April to the latter part of May and moths emerged from September 17 to October 1. He also records a quiescent period for the larva.

It will be noted that the main flight of moths in Illinois is distinctly earlier than in Tennessee, as is also the case in *Feltia ducens* and *F. subgothica*, under which this remarkable feature of the seasonal history is discussed.

Description of Stages

ADULT (PL. 4, I)

Grayish white with a brownish tinge more or less obscured by fuscous, the veins of the forewing margined with pale, the anterior margin of the costa rather pale, with a pale distinct transverse subapical line represented by dots between the veins and bordered inwardly with sagittate black dashes. The color of the costa of the forewings and the character of the subapical pale line will aid in distinguishing this species from *Feltia venerabilis*, which it rather closely resembles. Also the cell along the posterior margin of the forewing is rather completely filled with dark fuscous in *gladiaria* and is but slightly if at all darkened in *venerabilis*. Expanse from slightly over an inch to 1½ inches.

EGG

The egg is yellowish gray, circular in outline, 0.75 mm. broad and 0.65 mm. high, with about 68 close-set, rather ill-defined ribs made up of whitish contiguous scabroid granules, without transverse lines, and with the base smooth. About the second day after deposition the upper half of the egg becomes pinkish with a slightly darker belt and micropylar splotch, and later becomes an inconspicuous gray, which, some time before hatching, changes to plumbeous. The eggs are glued very firmly to the support and are probably normally deposited singly or only a few together. One moth in confinement deposited a total of 230 eggs.

LARVA

This larva has the head shield marked with fuscous reticulation (fig. 4, B); the skin granules are very small, but slightly convex, and set contiguously like the blocks in a pavement (fig. 4, J); setigerous tubercle II of the abdomen is twice as large as tubercle I; the spiracles are set in the dark supraspiracular coloration; and each anterior proleg in the adult larva bears about six crochets.

The above combination of characters will distinguish this species from all others with the exception of *Feltia venerabilis*, and these two larvae may be distinguished when in the last instar by the following characters:

Feltia venerabilis:

Dorsum uniform dark gray concolorous with the supraspiracular area, head shield 3.5 mm. broad, and basal portion of leg claw distinctly, acutely angulate.

Feltia gladiaria:

Dorsum distinctly paler than the supraspiracular area and tinged with ferruginous, head shield 3.2 mm. broad, and the basal portion of the leg claw broadly rounded, but slightly if at all angulate.

This larva presents the same markings and coloration in all instars after the third, except that the colors are darker in the earlier stages, with the exception of the dorsal area, which is gray to pale orange in the smaller larvae and becomes darker in the later instars.

First instar.—Head 0.34 mm. broad. Body about 3 to 3.6 mm. long and 0.5 mm. broad; skin set rather uniformly with isolated, coarse, conspicuous, pale fuscous granules; general color grayish, becoming nearly uniform ferruginous brown, the supraspiracular area infuscated, dorsally on posterior half of each abdominal segment two submedian pairs of converging pale lines, the usual middorsal and supraspiracular pale lines present, venter mottled with whitish. Head shield black. Setigerous tubercles large, pale fuscous, II slightly larger than I, III distinctly largest, their setae about one-third the length of an abdominal segment and strongly capitate. Functional prolegs on abdominal segments 5, 6, and 10.

Second instar.—Head 0.46 to 0.50 mm. broad. Body about 3.2 to 5 mm. long and 0.9 mm. broad; broadest through abdominal segments 1 to 4 and tapering both anteriorly and posteriorly; skin set rather closely with coarse rounded granules; general color a distinct ferruginous with fuscous brown markings, dorsal area ferruginous, supraspiracular area fuscous brown, the usual white middorsal and pair of supraspiracular lines, a pale band below spiracles, beneath pale mottled with ferruginous and white. Head shield uniform black. Setigerous tubercles dark fuscous, conical, tubercle II of abdomen distinctly much larger than I, III to V of about equal size, setae short, stout and capitate. Spiracles black. Legs brownish fuscous.

Third instar.—Head 0.72 to 0.76 mm. broad. Body about 6 to 10 mm. long and 1.2 mm. broad; tapering slightly posteriorly from about the fourth abdominal segment; skin set rather closely with coarse, round granules; general color brownish ferruginous overlaid laterally with fuscous, dorsal area sharply defined, clear brownish ferruginous, darker on the thorax, the usual middorsal and pair of supraspiracular pale lines, a band of pale flecks just below the spiracles, venter ferruginous with numerous white flecks. Head shield uniform black. Setigerous tubercles fuscous, II of abdomen twice as large as I, bearing short slightly capitate fuscous setae. Spiracles black. Legs fuscous. Prolegs functional on abdominal segments 5, 6, and 10, each with six to eight large brown crochets. The larva has a clumsy semilooper gait.

Fourth instar.—Head 1.1 to 1.2 mm. broad. Body about 14 mm. long and 2 mm. broad; tapering posteriorly from about the fourth abdominal segment; skin granules as in the mature larva; coloration as in the fifth instar but slightly darker in supraspiracular area, dorsum lighter, ferruginous. Setigerous tubercles as in fifth instar.

Fifth instar.—Head 1.9 to 2.2 mm. broad. Body about 20 to 27 mm. long and 4 mm. broad when extended; tapering slightly posteriorly from about the fourth abdominal segment; skin granules as in the sixth instar; general color pale semitranslucent grayish, somewhat darker in the supraspiracular area, with traces of pale fuscous and ferruginous, dorsal area sharply defined, paler than the supraspiracular area and tinged with ferruginous, the usual middorsal and supraspiracular pale lines, venter pale, flecked with white. Cervical shield distinct dark fuscous and brownish, with three pale stripes. Anal shield dark fuscous with three pale stripes and pale posteriorly. Head shield ground color pale brownish gray heavily overlaid with deep fuscous, the reticulation distinct only laterally, the adfrontal sutures terminating in the occipital foramen. Setigerous tubercles flat, dark fuscous, shining, tubercle II of abdomen about twice as large as I, II and V of about equal size, III smaller, IV much larger. Spiracles black. Legs brownish. Prolegs pale.

Sixth instar (pl. 6, C, I).—Head 3.1 to 3.2 mm. broad. Body about 37 mm. long and 5.5 mm. broad when extended; tapering posteriorly from about the fourth abdominal segment; skin set with flat or very slightly convex shining granules about one-fiftieth of a millimeter broad, which are contiguous or only very slightly separated from each other; color very pale, semitranslucent, shining grayish, varying to slightly darker, with traces of pale fuscous and ferruginous, very little darker in the supraspiracular area, dorsal area sharply defined, distinctly paler than the supraspiracular area, and tinged with ferruginous, venter waxy gray varying to dusky grayish. Head shield grayish brown with fuscous submedian arcs and reticulation, the adfrontal sutures terminating in the occipital foramen. Setigerous tubercle II of the abdomen twice as large as tubercle I, II and IV of about equal size, III equal to V or slightly smaller, IV much larger. Spiracles black. Legs with the basal portion of the claw broadly rounded, but slightly, if at all, angulate. Prolegs on abdominal segments 3, 4, 5, 6, and 10, each anterior proleg with about six crochets.

Mouth parts: Mandibles of the ordinary type. Hypopharynx as in *Agrotis ypsilon*, the lingua occupying about one-third of the length of the part, blade of the maxillulae with about 25 to 30 broad, flat, contiguous teeth. Labial palpi with the segments in the proportion of 22, 2.5, and 10.

Setae and punctures of the head: O^2 somewhat nearer to L^1 than to A^3. SO^3 distinctly nearer to G^1 than to O^3. Arrangement of setae and punctures otherwise as in *Feltia annexa.*

PUPA

Pupa (fig. 19, A) about 13 to 19 mm. long and 5 to 6 mm. broad, prespiracular callus present on prothorax, punctures on movably linked abdominal segments round, spiracles broad, directed laterally, cremaster without accessory spinules, the spines rather short, divergent, set on a conical base.

LIFE HISTORY

EGG STAGE

TABLE 16.—*Duration of egg stage in Feltia gladiaria*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Oct. 9, 1913	Nov. 16, 1913	38	53.8	Oct. 9, 1914	Nov. 30, 1914	52	55.6
Oct. 10, 1913	do	37	53.2	Do	Dec. 7, 1914	59	52.6
Oct. 12, 1913	do	35	52.8	Oct. 5, 1914	Dec. 8, 1914	64	54.5

In the first three of the above records the eggs were deposited in a sunny spot on the wire screen of an outdoor cage. In the last three the eggs were deposited in glass tubes which were kept in a shaded porch. It is probable that the conditions were more nearly normal in the first series and that the egg stage in nature requires about 5 or 6 weeks.

LARVAL STAGE

Larvae which hatched on the night of November 16, 1913, were in the last instar March 23, 1914, giving a period of about 4 months for the active larval stage. The aestivating stage ranges in duration from about 3½ to 5 months, the entire larval stage occupying a period of from 7½ to 9 months.

AESTIVATING AND PUPAL STAGES

TABLE 17.—*Duration of aestivating and pupal stages in Feltia gladiaria*

Entered cell	Pupated night of—	Emerged night of—	Aestivating stage	Pupal stage	Average mean temperature
1914	1914	1914	*Days*	*Days*	° *F.*
May 7	Aug. 28	Sept. 27	113	30	72.2
7	28	29	113	32	71.8
14	28	30	106	33	71.7
14	[1] 30	30	108	31	71.9
4	31	Oct. 1	119	31	71.2
14	29	1	107	33	71.3
21	30	1	101	32	74.5
	30	1		32	74.5
	Sept. 1	1		30	70.8
7	3	5	119	32	70.3
Apr. 2	1	8	152	37	70.7

[1] Two individuals.

Parasites and Predators

In 1921, 297 larvae were collected in the field when nearly mature and reared singly in tin boxes with unsterilized field earth. Mortality was as follows:

Moths emerged		3
Parasitized		127
Insects:		
Ophion sp	24 larvae.	
Meteorus vulgaris Cress	8 larvae.	
Diseases:		
Beauveria sp	23 larvae.	
Metarrhizium anisopliae	18 (17 larvae, 1 pupa).	
Sorosporella uvella (Krass.)	10 larvae.	
Entomophthora sp	2 larvae.	
Botrytis rileyi Farl	2 larvae.	
Penicillium (*briardi* Vuill.?)	3 larvae.	
Fusarium sp	2 larvae (possibly not parasitic).	
Undetermined fungus disease	12 larvae.	
Polyhedral disease (?)	8 larvae.	
Bacteria	14 larvae (may not have caused death).	
Protozoan infestation (?)	1 larva.	
Larvae dead without apparent cause		166
Pupa dead without apparent cause		1

Meteorus vulgaris larvae often emerge to the number of 12 or more from a larva of the host after the latter is dead. Emergence occurs chiefly in May. The eggs of the Ophion are polished and brownish-black in color. They are usually deposited laterally on the prothorax to the number of from 1 to 5, 2 or 3 being the usual number. They are attached at one end by a very short pedicel.

Apanteles griffinii Vier. and *Ophion bilineatus* Say have also been obtained as parasites of the larva.

The spider *Lycosa helluo* Walck. has been seen feeding on larvae of *gladiaria* on several occasions. A minute spider, determined by Shoemaker as *Misumessus asperatus* Hentz, was collected on a spray of goldenrod with a moth of this species in its grasp. The spider weighed 0.02 gram and the depleted moth weighed 0.05 gram. Larvae have been taken bearing clusters of brownish mites which were determined by Banks as a species of Uropoda, with the comment that they were not predacious but merely used the larva for migration.

Forbes (*26*) records a species of Meteorus from larvae, and there is a record of the breeding of *Ophion bilineatum* Say from this species (*75, p. 155*). Muesebeck (*50*) records *Meteorus vulgaris* Cress. as a parasite and *Microplitis feltiae* Mues. is also so recorded (*49*).

THE DUSKY CUTWORM, FELTIA VENERABILIS WLK.

Distribution

This species occurs throughout the east and west breadth of the United States in the North, at least, and in Manitoba and Ontario. The recorded southern range includes California, Colorado, Texas, Tennessee, and Virginia. The Texas record would seem to indicate that the species should occur in the region south of Tennessee and Virginia, but the writer has taken no larvae and only two moths at

Clarksville, Tenn., and much collecting in Virginia has yielded only three larvae.

Moths have been reared from larvae from South Boston, Va.; Sioux City, Iowa; Geddes, S. Dak.; Mott and Dickinson, N. Dak.; Uvalde, Tex.; and Victoria, Tex.

Food Plants

The writer has had no field experience with this species, but has reared larvae on clover and chickweed. Little has been written concerning it. Gibson (*33*) records that larvae are injurious to plants in vegetable gardens and also to oats. Although this species has not been reported as feeding on tobacco, it is included here owing to its wide distribution in tobacco-growing districts, which makes it very probable that the larva will be found to injure this crop.

Seasonal History and Life History

This species has one brood during the year. The winter is passed in the larval stage, and the larvae have a long aestivating stage beginning in the spring. They pupate in the fall, producing moths in September, October, and November.

The available data on this species are meager, but enough to show that the above scanty outline of the seasonal history is correct for the conditions occurring at Sioux City, Iowa, from which most of the material reared has been derived through C. N. Ainslie. Two moths were taken in light traps at Clarksville, Tenn., one October 7, 1913, and one October 7, 1918.

In October and November the pupal stage was 56 to 62 days in duration.

Description of Stages

ADULT (PL. 4, J)

Pale gray tinged with brownish, more or less obscured by fuscous, the veins of the forewings margined with pale, the anterior margin of the costa dark, the subapical pale line and accompanying interior sagittate dark dashes obscure. This species resembles *gladiaria* rather closely, and some of the characters distinguishing the two are discussed under that species. Expanse about 1½ inches.

EGG

The egg is white, circular in outline, 0.76 mm. broad and 0.69 mm. high, with about 42 heavy, sinuate, but slightly elevated ribs and many ill-defined coarse transverse lines. The base is obscurely reticulate. This description was drawn up from infertile eggs.

LARVA

The coloration of the head shield in this species is of the reticulated type, as distinguished from the flecked or tessellated coloration found in the species of the Euxoa group; the skin is finely pavement-granulose; tubercle II of the abdomen is distinctly twice as large as tubercle I; the spiracles are set in the dark dorsal coloration; and each anterior proleg, in the mature larva, is provided with about seven crochets. The above combination of characters will distinguish this species from all but *Feltia gladiaria* and the differences between these larvae are discussed under *gladiaria*.

Mature larva (pl. 6, D, J).—Head 3.3 to 3.5 mm. broad. Body about 40 to 43 mm. long and 6.5 mm. broad; very slightly broader through abdominal segments 3, 4, and 5, each segment having a convex lateral outline; skin very finely pavement-granulose (fig. 4, J); coloration above the spiracles nearly uniform dark dull grayish varying to nearly black, obscurely flecked with pale, the dorsal area faintly paler, especially laterally, with traces of middorsal, subdorsal, and a pair of supraspiracular pale lines, a band of pale flecks just below the spiracles, venter dull plumbeous gray obscurely flecked with pale. Head shield ground color very pale brownish, the submedian fuscous arcs heavy, much broader above, above the base of the antennae and extending nearly half-way to the apex of the head shield along the submedian arcs, an area in which all the fuscous reticulation is absent, the reticulation thus being unusually limited; the adfrontal sutures terminating in the occipital foramen. Setigerous tubercle II of abdomen about twice as large as I, III about as large as II, IV distinctly much larger than I to III. Spiracles black. Legs pale brownish, the basal portion of the claw distinctly, acutely angular. Prolegs concolorous with venter, each proleg of the anterior pair with about five to nine crochets.

Mouth parts: Mandibles of the ordinary type. Hypopharynx as in *Agrotis ypsilon*, the lingua occupying about half the length of the part, the blade of the maxillulae with about 30 broad, flat, bluntly pointed teeth. Spinneret broad and short with a median apical notch. Labial palpi with the segments in the proportion of 24, 2, and 6.

Setae and punctures of the head: O^2 slightly nearer to L^1 than to A^3. SO^a somewhat nearer to SO^2 than to SO^3. SO^3 distinctly nearer to G^1 than to O^3. G^1 distinctly nearer to G^a than to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 18 mm. long and 5.5 mm. broad, maxillary palpi not visible, labrum scarcely emarginate, prespiracular callus present on prothorax, punctures on movably linked abdominal segments very fine, round, in several rows, cremaster with one pair of accessory spinules, spines divergent, set on a rather distinct process, with a coarsely rugulose area both below and anterior to the spines.

PARASITES

From larvae of this species received from Sioux City, Iowa, two syrphid flies were obtained which were determined by Aldrich as *Anthrax alternata* Say (= *scrobiculata* Loew). This species was reared from cutworms by Gillette in Iowa (*74*). From larvae from the above locality the writer has obtained *Bonnettia compta* Fall. A large cocoon, apparently that of an Ophion, was obtained from larvae sent from Victoria, Tex., by J. D. Mitchell.

THE GRANULATED CUTWORM, FELTIA ANNEXA TREIT.

DISTRIBUTION

Feltia annexa occurs from Massachusetts and New York westward to South Dakota, Arizona, and California, but probably does not breed regularly in the northern parts of this range and is usually common only in the region south of the latitude of the Ohio River. It is most abundant in the extreme South. Its range also includes the Bahama Islands, Cuba, Porto Rico, Central America, and South America. Larvae have been examined from Bowling Green, Ky., Clarksville, Tenn., South Boston, Va., Phoenix, Ariz., Uvalde, Tex., Solitude and Baton Rouge, La., Quincy and Dade City, Fla., and the Bahama Islands. Bruner (*6*) states that larvae were abundant in Nebraska in 1889, and Smith (*61*) has found them sometimes injurious in New Jersey.

Food Plants

The larvae have been observed to feed on Amaranthus, bean, beets, Brussels sprouts, cabbage, cauliflower, clover, cocklebur, corn, cotton, dandelion, eggplant, grass, knot grass (*Polygonum aviculare*), apple of Peru (*Nicandra physalodes*), passion vine, pea, pepper, plantain, potato, shepherd's purse, sweet potato, tobacco, tomato, turnip, and wheat.

Food Habits

The larvae are present throughout the growing season of tobacco. When the plants are young the larvae sever the stems, but as the tobacco grows too large for the normal manifestation of the cutworm habit the larvae climb the plants and sever the midribs of leaves near the base of the plant, usually at some distance from the base of the leaf, and then feed upon the portion which lies upon the soil; concealing themselves slightly in the daytime beneath their sources of food but often lying with the dorsum exposed. The life of the leaf is usually still maintained through the intact portion of the blade. In addition to severing the leaves of the larger tobacco plants, the larvae also gnaw off the epidermis of the stems at or below the surface of the ground and even at some distance above the ground, and this may severely check the development of plants.

The larvae also are able to live for at least a month on dry vegetation, upon which they seem to thrive. This adaptation must prove of value to the species during protracted droughts such as those experienced in 1913 and 1914 and may be one of the factors accounting for the unusually rapid increase in numbers in summer, when most multiple-brooded species grow scarce.

At Clarksville this is by far the most common species found in tobacco fields in the fall, but it is uncommon at other seasons. Jones (*40*) has found it to be the principal cutworm attacking vegetables in Louisiana, where it comprised 76 per cent of all larvae collected injuring plants in 1915, 1916, and 1917. The larva has also received notice as an enemy of cotton, corn, and beets among field crops.

Seasonal History

This species has three full broods and an additional abortive one late in the fall.

Moths begin to emerge in the spring prior to the latter part of March and produce mature larvae by the latter part of May, the main oviposition occurring probably about the first week in May. Moths of the second brood begin to emerge in early June and mature larvae from these begin to appear the latter part of June, the moths continuing to emerge until early in August. The main oviposition by the second-brood moths occurs about the middle of July. Moths of the third brood begin to emerge the latter part of July and continue to emerge until at least the middle of November, the majority appearing about the middle of September. The earlier members of the brood produce an additional brood of moths the same fall, but the progeny of these moths are killed by the cold before pupation. The September moths produce overwintering pupae.

Jones (*40*) has found that there are apparently five and possibly six generations during the year in Louisiana and that larvae are probably present throughout the season, having been collected in every month except March, May, and September. He has collected moths in every month except April and June. Eggs deposited as late as December were not all killed by the cold, and some of the larvae which hatched January 6 survived.

Description of Stages

ADULT (PL. 4, E)

Thorax and forewings yellowish brown, more or less infuscated, the collar rather dark with a distinct black line, the abdomen gray, the hind wings pure white with the veins and a slight border sometimes infuscated. The orbicular spot is small, rounded, and connected with the reniform spot by a characteristic, sharply defined black dash. Expanse from slightly less than 1½ to 1¾ inches.

EGG

The egg is white, flattish, 0.63 mm. broad and 0.50 mm. high, with about 36 to 40 straight slender ribs and many fine transverse lines. The second day after deposition a belt and micropylar splotch of pinkish ferruginous appear.

The eggs are deposited singly or a few together on the foliage of plants, in cultivated fields exclusively. The writer has collected many thousand larvae of this species and has not noted a single exception to this rule. One moth in confinement deposited 403 eggs and three others deposited an average of 325 eggs each.

LARVA

This species may be positively identified by the presence of isolated, somewhat retrorse, conical skin granules (fig. 4, G) in a larva with setigerous tubercle II of the abdomen distinctly twice as large as I. The dorsal coloration is also very characteristic, although difficult to describe, and the larva is flecked with white ventrally to an unusual degree.

This species normally buries itself very shallowly in the soil, often lying with the dorsum uncovered, and the peculiar conical, retrorse skin granules cause a coating of dust to be retained on the skin as the larva moves through the cultivated soil with which it is habitually associated, thus rendering the insect quite inconspicuous. Larvae such as that of *Agrotis ypsilon*, when uncovered in the soil, are always clean and conspicuous and hence have more need of their habit of burrowing deeply.

First instar.—Head 0.34 mm. broad. Body about 2 to 3.5 mm. long; pale; skin set with minute rounded granules. Cervical shield fuscous with pale areas about the bases of the anterior setae. Head shield dark fuscous. Setigerous tubercles of abdomen large, conical, fuscous, of about equal size, bearing very long, curved, strongly capitate setae. Prolegs on abdominal segments 5, 6, and 10. Legs brownish fuscous. Anal shield entire.

Second instar.—Head 0.5 mm. broad. Body about 5 to 6 mm. long and 0.8 mm. broad; broadest through about the first four abdominal segments and tapering slightly both anteriorly and posteriorly; skin set closely with minute papillae; above the spiracles grayish overlaid with brownish or sometimes with yellowish brown and ferruginous, a continuous middorsal line and pair of supraspiracular lines white, below the spiracle pale with large white splotches. Anal shield concolorous with adjacent parts. Cervical shield pale brownish with fuscous flecks. Head shield deep fuscous. Setigerous tubercles fuscous, prominent, I to V of about equal size, bearing long, strongly capitate, curved, fuscous setae. Spiracles protuberant. Legs pale brownish, fuscous apically. Functional prolegs on abdominal segments 4, 5, 6, and 10.

Third instar.—Head 1 mm. broad. Body about 12 mm. long and 2 mm. broad; tapering slightly posteriorly; skin coarsely granulose; general color grayish overlaid with brownish and ferruginous, middorsal and supraspiracular pale lines broken and indistinct, pale ventrally. Head shield brown infuscated dorsally and at the ocelli. Setigerous tubercle II of abdomen distinctly much larger than I. Prolegs present on abdominal segments 3, 4, 5, 6, and 10. Other details as in second instar.

Fourth instar.—Head 1.5 mm. broad. Body about 17 mm. long and 2.5 mm. broad; tapering slightly posteriorly; skin closely, rather coarsely granulose much as in the sixth instar; general color gray; dorsal area overlaid with sandy brown and fuscous, a pale middorsal line demarked with fuscous and a segmental series of fuscous V-shaped figures, subdorsally to the spiracles a fuscous band mottled with gray, below the spiracles a band of pale flecks, beneath pale. Head shield ground color pale brown, the submedian arcs and contiguous reticulation fuscous. Setigerous tubercle II of abdomen about twice as large as I, III, IV, and V of about equal size. Spiracles black. Legs very pale brownish. Prolegs pale, functional on abdominal segments 3, 4, 5, 6, and 10.

Fifth instar.—Head 2.1 to 2.5 mm. broad. Body about 22 mm. long and 3.5 mm. broad; of nearly uniform width throughout; skin set closely with conical granules much as in the sixth instar; general color grayish white, dorsal area overlaid with fuscous and sandy brown, the pale broken middorsal line demarked with fuscous especially at the juncture of the segments, V-shaped segmental figures less distinct than in the preceding instar, subdorsally to and including the spiracles a fuscous band much mottled with white and grayish especially below. Anal shield fuscous with a broad median stripe. Cervical shield brownish with fuscous markings. Head shield ground color dingy yellowish or brownish with fuscous submedian arcs and reticulation, the dorsal reticulation more or less obsolete. Spiracles black. Setigerous tubercle II of abdomen distinctly twice as large as I, II and IV of about equal size, III and V smaller, all corrugated and more or less fuscous. Legs pale, tinged with brownish apically. Prolegs pale.

Sixth instar (pl. 6, E, K).—Head 3 mm. broad. Body about 30 to 37 mm. long and 5 to 6 mm. broad; tapering slightly posteriorly, the posterior extremity rather blunt; skin set with slightly isolated, bluntly conical, somewhat retrorse, chitinous granules interspersed irregularly among many minute secondary granules; dorsum ashy gray overlaid with sandy brown and ferruginous, sides darker, beneath heavily splotched with white. Head shield ground color pale brownish or yellowish, reticulate with fuscous and ferruginous, reticulation usually more or less obsolete, the adfrontal sutures terminating in the occipital foramen. Setigerous tubercle II of abdomen twice as large as I, IV about twice as large as III. Spiracles black. Each anterior proleg with about 8 to 12 crochets.

Mouth parts: Mandibles of the ordinary type. Hypopharynx as in *Agrotis ypsilon*, the blade of the maxillulae with about 20 to 30 teeth. Spinneret broad and short with a median apical notch. Labial palpi with segments in the proportion of 25, 2.5, and 8.5.

Setae and punctures of head: The following is a complete presentation of the relationships of the head setae and punctures as applied in the present investigation. In all the other species the list of comparisons has been curtailed to include only such as were found to vary from the conditions prevailing in *Feltia annexa*.

A^2 approximately equidistant from A^1 and A^3 or slightly nearer to A^1.
A^2 nearer to A^a than to A^1.
A^2 distinctly nearer to A^1 than to P^a.
A^a equidistant from A^2 and A^3 or nearer A^2.
A^a equidistant from A^2 and P^a or nearer A^2.
A^3 distinctly less than the ocellar width from ocellus II.
P^1 decidedly nearer to Adf^1 than to Adf^2.
P^1 decidedly below the level of Adf^2.
P^a, A^a, and A^2 not in a straight line.
P^a on or very near the level of Adf^1.
P^a, A^a, and A^3 not in a straight line.
P^b, A^2, and A^1 approximately in a straight line.
Interspace A^2–A^a shorter than P^1–P^a.
Adf^2 distinctly nearer to P^1 than to P^2.
O^1 posterior to the line connecting the centers of ocelli IV and VI.
Punctures F^a on the level of setae F^1.
Interspace E^1–E^2 somewhat greater than F^1–F^a.
P^b somewhat nearer to P^2 than to P^1.
Adf^a distinctly nearer to Adf^2 than to Adf^1.

P^2, P^1, and Adf^1 not in a straight line.
Adf^2 above the apex of the front.
Ocellus VI somewhat nearer to O^1 than to O^3.
O^2 nearly or quite equidistant from L^1 and A^3.
O^2 nearly or quite equidistant from A^3 and O^1.
O^a less than the ocellar width removed from ocellus VI and distinctly nearer to VI than to O^3.
L^1 distinctly nearer to L^a than to O^2.
SO^a approximately equidistant from SO^2 and SO^3.
SO^3 equidistant from G^1 and O^3 or nearer to G^1.
G^1 approximately equidistant from SO^3 and O^3.
G^a usually approximately equidistant from G^1 and O^3.
G^1 approximately equidistant from SO^3 and G^a or somewhat nearer to G^a.

PUPA

Pupa (fig. 19, F) about 15 to 20 mm. long and 5 to 6 mm. broad, maxillary palpi visible, labrum emarginate, prespiracular callus present on prothorax, punctures on movably linked abdominal segments oval, spiracles broad, directed laterally, cremaster usually with two pairs of accessory spinules, spines set on a distinct process, their bases enlarged, their outer margins nearly parallel, and their inner margins divergent from the base, the areas anterior to and below the spines obscurely rugulose.

Several dozen pupal cells examined in a cultivated tobacco field were found to be set perpendicularly in nearly every case and within an inch of the surface.

LIFE HISTORY

TABLE 18.—*Length of generations in Feltia annexa*

Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
		Days	° *F.*		*Days*	° *F.*		*Days*	° *F.*	*Days*	° *F.*
July 25, 1914	July 28, 1914	3	88.3	Aug. 25, 1914	28	80.2	Sept. 10, 1914	16	75.4	47	79.1
Do	do	3	88.3	Aug. 23, 1914 [1]	26	79.9	do	18	76.2	47	79.0
Do	do	3	88.3	Aug. 25, 1914 [2]	28	80.2	Sept. 11, 1914	17	75.4	48	78.9
Do	do	3	88.3	do	28	80.2	do	17	75.4	48	79.0
Do	do	3	88.3	Aug. 24, 1914	27	80.2	do	18	75.6	48	79.0
Do	do	3	88.3	Aug. 25, 1914	27.5	80.2	Sept. 12, 1914	18.5	74.9	49	78.7
Do	do	3	88.3	Aug. 27, 1914	30	80.0	Sept. 13, 1914	17	74.0	50	78.4
Do	do	3	88.3	Aug. 29, 1914	32	79.6	Sept. 14, 1914	16	74.3	51	78.4
Do	do	3	88.3	Aug. 26, 1914	29	80.1	do	19	74.3	51	78.4
Do	do	3	88.3	Aug. 28, 1914	31	79.9	Sept. 18, 1914	21	73.7	55	78.0
Do	do	3	88.3	Aug. 29, 1914	32	79.6	Sept. 19, 1914	21	74.0	56	78.0
Do	do	3	88.3	Sept. 2, 1914	36	79.4	Sept. 20, 1914	18	73.4	57	78.0
Aug. 3, 1915	Aug. 8, 1915	5	74.6	Sept. 4, 1915	27	73.7	Sept. 22, 1915	18	77.5	50	75.1
Do	do	5	74.6	Sept. 5, 1915	28	73.9	Sept. 23, 1915	18	76.6	51	74.9
Do	do	5	74.6	Sept. 10, 1915	33	75.0	Sept. 25, 1915	15	74.3	53	74.8
Do	do	5	74.6	do. [2]	33	75.0	Sept. 26, 1915	16	74.4	54	74.8
Aug. 4, 1916	Aug. 7, 1916	3	82.5	Sept. 6, 1916	30	76.6	Sept. 28, 1916	22	67.1	55	73.1
Aug. 3, 1915	Aug. 8, 1915	5	74.6	Sept. 13, 1915 [3]	36	75.6	Sept. 29, 1915	16	72.7	57	74.7
July 25, 1914	July 28, 1914	3	88.8	Sept. 8, 1914	42	78.8	Sept. 29, 1914	21	69.7	66	76.3
Aug. 6, 1915	Aug. 11, 1915	5	78.6	Sept. 11, 1915	31	74.5	Sept. 29, 1915	18	73.8	54	74.5
Do	do	5	78.6	Sept. 15, 1915	35	75.3	do	14	71.4	54	74.6
Aug. 3, 1915	Aug. 8, 1915	5	74.6	Sept. 13, 1915	36	75.4	Oct. 1, 1915	18	71.8	59	74.2
Do	do	5	74.6	do	36	75.4	Oct. 2, 1915	19	71.4	60	74.1
Do	do	5	74.6	Sept. 14, 1915	37	75.6	Oct. 3, 1915	19	70.8	61	74.0
Aug. 2, 1916	Aug. 6, 1916	4	74.9	Sept. 7, 1916	32	76.9	Oct. 4, 1916	27	64.0	63	71.2
Aug. 6, 1915	Aug. 11, 1915	5	78.6	Sept. 17, 1915	37	75.6	Oct. 4, 1915	17	69.2	59	74.0
Aug. 3, 1915	Aug. 8, 1915	5	74.6	Sept. 16, 1915	39	75.8	Oct. 5, 1915	19	69.1	63	73.7
Do	do	5	74.6	Sept. 14, 1915	37	75.6	Oct. 6, 1915	22	69.4	64	73.4
Aug. 6, 1915	Aug. 11, 1915	5	78.6	Sept. 17, 1915	37	75.6	do	19	67.6	61	73.3
Do	do	5	78.6	do	37	75.6	Oct. 7, 1915	20	66.9	62	73.0
Aug. 5, 1916	Aug. 9, 1916	4	78.9	Sept. 11, 1916	33	76.7	Oct. 9, 1916	28	63.7	65	71.2
Aug. 4, 1916	Aug. 7, 1916	3	82.3	do	35	76.6	do	28	63.7	66	71.3
Aug. 5, 1916	Aug. 9, 1916	4	78.9	Sept. 9, 1916	31	76.7	do	30	64.5	65	71.2
Do	do	4	78.9	Sept. 10, 1916	32	76.6	do	29	64.1	65	71.1
Aug. 3, 1915	Aug. 8, 1915	5	74.6	Sept. 16, 1915	39	75.8	Oct. 10, 1915	24	64.9	68	71.9
Aug. 6, 1915	Aug. 11, 1915	5	78.6	Sept. 17, 1915	37	75.6	do	23	64.3	65	71.8

[1] 2 individuals. [2] 3 individuals. [3] 4 individuals.

TABLE 18.—*Length of generations in Feltia annexa*—Continued

Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
		Days	° *F.*		*Days*	° *F.*		*Days*	° *F.*	*Days*	° *F.*
Aug. 3, 1915	Aug. 8, 1915	5	74.6	Sept. 17, 1915 [1]	40	75.9	Oct. 10, 1915	23	64.3	68	71.9
Do	do	5	74.6	Sept. 18, 1915	41	76.0	Oct. 11, 1915	23	63.3	69	71.7
Do	do	5	74.6	Sept. 17, 1915 [1]	40	75.9	Oct. 12, 1915	25	63.7	70	71.4
Aug. 5, 1916	Aug. 9, 1916	4	78.9	Sept. 15, 1916	37	75.9	Oct. 12, 1916	27	62.1	68	70.6
Aug. 4, 1916	Aug. 7, 1916	3	82.3	Sept. 12, 1916	36	76.5	Oct. 13, 1916	31	62.8	70	70.7
Do	do	3	82.3	Sept. 13, 1916	37	76.4	do	30	62.5	70	70.7
Aug. 3, 1915	Aug. 8, 1915	5	74.6	Sept. 19, 1915	42	75.9	Oct. 14, 1915	25	62.7	72	71.2
Aug. 4, 1916	Aug. 7, 1916	3	82.3	Sept. 13, 1916 [1]	37	76.4	Oct. 14, 1916	31	62.3	71	70.5
Aug. 2, 1916	Aug. 6, 1916	4	81.7	do. [1]	38	76.6	Oct. 15, 1916	32	62.5	74	70.8
Do	do	4	81.7	Sept. 14, 1916 [4]	39	76.4	do	31	62.2	74	70.7
Aug. 3, 1915	do	5	74.6	Sept. 20, 1915	43	76.0	Oct. 16, 1915	26	62.6	74	71.2
Do	do	5	74.6	Sept. 19, 1915	42	75.9	Oct. 17, 1915	28	63.1	75	71.0
Aug. 6, 1915	Aug. 11, 1915	5	78.6	Sept. 22, 1915	42	74.9	Oct. 19, 1915	27	63.6	74	71.0
Aug. 4, 1916	Aug. 7, 1916	3	82.3	Sept. 17, 1916	41	74.9	Oct. 19, 1916	32	62.5	76	70.0
Do	do	3	82.3	Sept. 21, 1916	45	73.6	do	28	62.8	76	70.0
Aug. 2, 1916	Aug. 6, 1916	4	81.7	Sept. 19, 1916	44	74.3	do	30	62.9	78	70.3
Aug. 6, 1916	Aug. 10, 1916	4	78.4	do	40	73.9	Oct. 20, 1916	31	62.5	75	69.4
Aug. 4, 1916	Aug. 7, 1916	3	82.3	Sept. 18, 1916	42	74.5	do	32	62.4	77	69.8
Do	do	3	82.3	Sept. 21, 1916	45	73.6	do	29	62.5	77	69.8
Do	do	3	82.3	do. [1]	45	73.6	Oct. 27, 1916	36	59.9	84	68.0
Do	do	3	82.3	Sept. 23, 1916	47	73.0	Oct. 28, 1916	35	59.8	85	67.9
Do	do	3	82.3	Sept. 25, 1916 [1]	49	72.6	do	33	59.1	85	67.7
Do	do	3	82.3	Sept. 22, 1916	46	73.3	Oct. 29, 1916	37	60.2	86	68.0
Aug. 6, 1916	Aug. 10, 1916	4	78.4	Sept. 20, 1916	41	73.6	do	39	60.3	84	67.6
Aug. 4, 1916	Aug. 7, 1916	3	82.3	Sept. 26, 1916 [2]	50	72.7	do	33	59.6	86	68.0
Do	do	3	82.3	Sept. 24, 1916	48	72.8	do	35	60.2	86	68.0
Aug. 2, 1916	Aug. 6, 1916	4	81.7	Sept. 23, 1916	48	73.2	Oct. 30, 1916	37	60.1	89	68.1
Do	do	4	81.7	Sept. 24, 1916	49	73.0	do	36	60.2	89	68.2
Aug. 6, 1916	Aug. 10, 1916	4	78.4	Sept. 25, 1916	46	72.4	do	35	60.0	85	67.6
Do	do	4	78.4	Sept. 26, 1916	47	72.4	Nov. 2, 1916	37	59.1	88	67.1
Aug. 4, 1916	Aug. 7, 1916	3	82.3	Sept. 25, 1916	49	74.8	Nov. 4, 1916	40	59.0	92	68.2
Aug. 6, 1915	Aug. 11, 1915	5	78.6	Oct. 5, 1915	55	73.3	Nov. 4, 1915	30	61.2	90	69.6
Aug. 4, 1916	Aug. 7, 1916	3	82.3	Sept. 25, 1916 [1]	49	72.7	Nov. 5, 1916	41	59.1	93	67.0

[1] 2 individuals. [2] 3 individuals. [4] Afternoon.

PREOVIPOSITION PERIOD

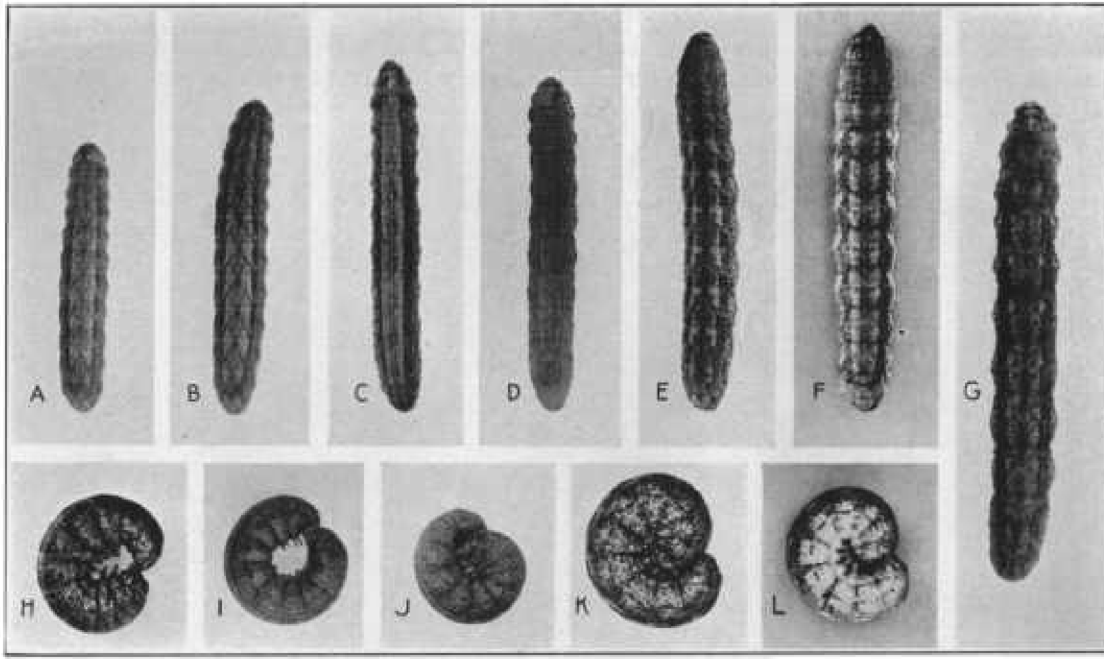
One moth emerged on the night of July 30, 1916, and three others emerged on the night of July 31. Fertile eggs were obtained from these on August 2, two or three days after emergence.

EGG STAGE

TABLE 19.—*Duration of the egg stage in Feltia annexa*

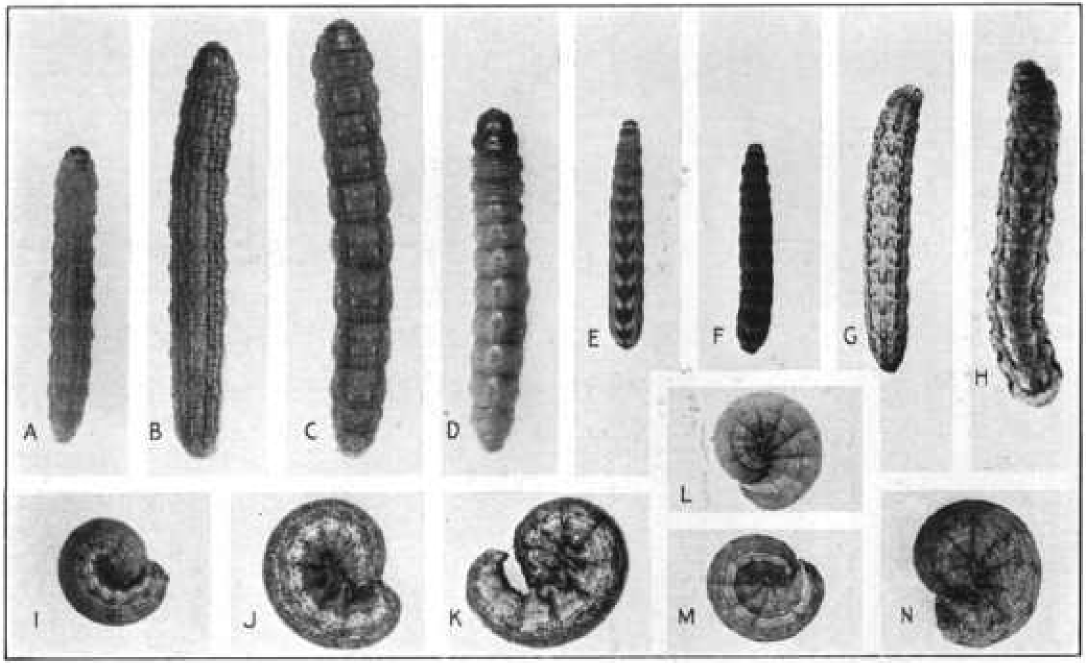
Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
July 25, 1914	July 28, 1914	3	88.3	Sept. 13, 1917	Sept. 19, 1917	6	70.2
Aug. 1, 1915	Aug. 6, 1915 [1]	5	76.4	Sept. 17, 1914	Sept. 21, 1914 [1]	4	77.5
Aug. 2, 1916	Aug. 6, 1916	4	81.7	Sept. 24, 1914	Oct. 2, 1914 [2]	7.5	64.7
Aug. 4, 1916	Aug. 7, 1916	3	82.3	Do	Oct. 3, 1914 [2]	8.5	65.0
Aug. 3, 1915	Aug. 8, 1915	5	74.6	Sept. 29, 1914	Oct. 6, 1914	7	68.6
Aug. 5, 1916	Aug. 9, 1916	4	78.8	Sept. 30, 1914	do	6	68.6
Aug. 6, 1916	Aug. 10, 1916	4	78.3	Oct. 20, 1915	Oct. 31, 1915	11	59.3
Aug. 30, 1915	Sept. 5, 1915	6	71.2	Do	Nov. 2, 1915	13	59.7
Sept. 1, 1915	Sept. 6, 1915	5	75.3	Oct. 22, 1915	do	11	59.8
Sept. 3, 1913	Sept. 7, 1913	4	82.5	Do	Nov. 3, 1915	12	58.8
Sept. 6, 1911	Sept. 10, 1911	4	78.0				

[1] 2 individuals. [2] Afternoon.



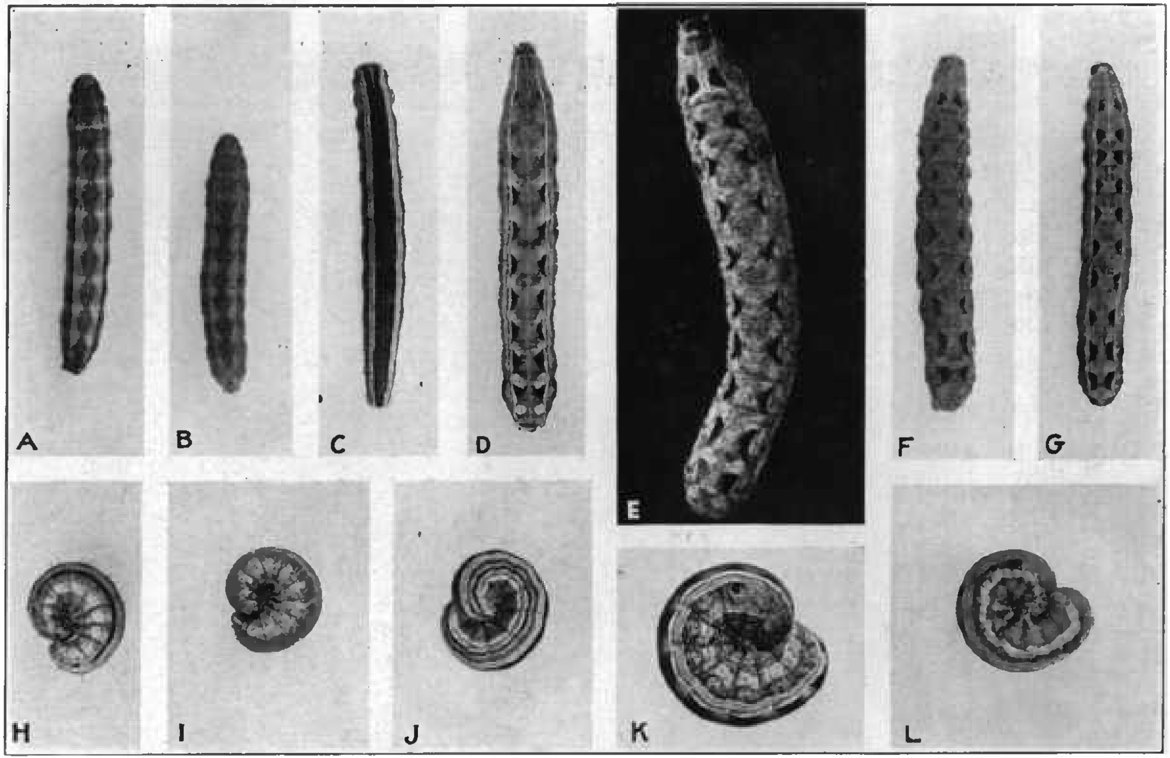
LARVAE OF SPECIES OF FELTIA

A, *Feltia ducens*, dorsal view; B, *F. subgothica*, dorsal view; C, *F. gladiaria*, dorsal view; D, *F. venerabilis*, dorsal view; E, *F. annexa*, dorsal view; F, *F. malefida*, dorsal view, light phase; G, *F. malefida*, dorsal view, dark phase; H, *F. ducens*, lateral view; I, *F. gladiaria*, lateral view; J, *F. venerabilis*, lateral view; K, *F. annexa*, lateral view; L, *F. malefida*, lateral view. × 1.3.



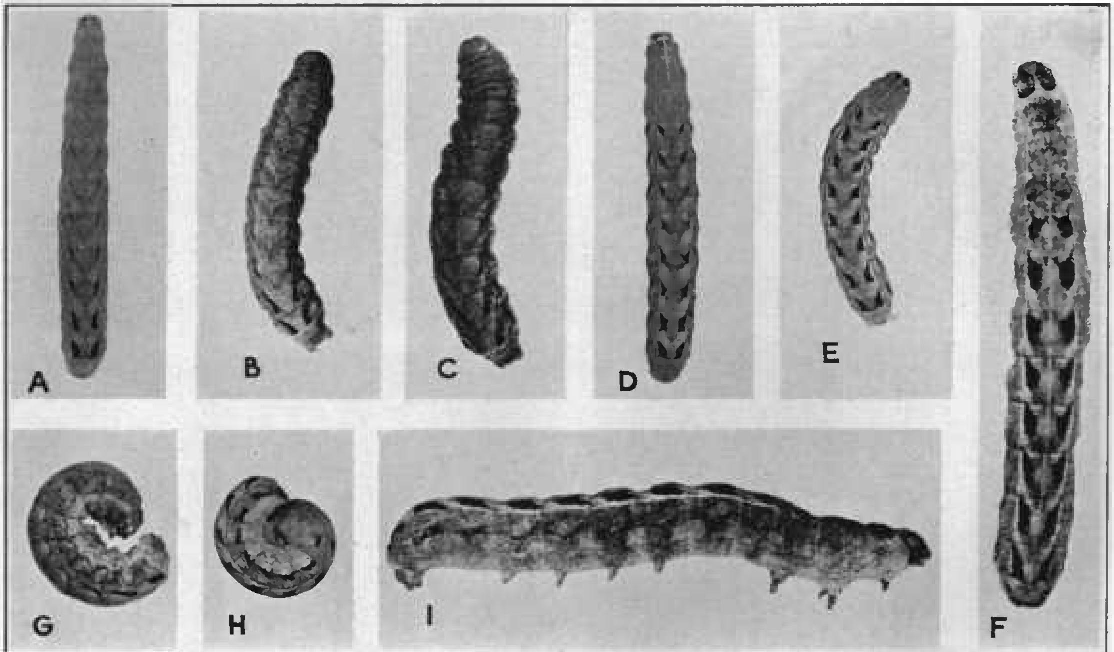
LARVAE OF SPECIES OF CHORIZAGROTIS, EUXOA, AGROTIS, AGROPERINA, PARASTICHTIS, AND LYCOPHOTIA

A, *Chorizagrotis auxiliaris*, dorsal view; B, *Euxoa messoria*, dorsal view; C, *Agrotis ypsilon*, dorsal view; D, *Agroperina lutosa*, dorsal view; E, *Parastichtis bicolorago*, dorsal view, dark phase; F, *P. bicolorago*, dorsal view, light phase; G, *Lycophotia infecta*, dorsal view, brown phase; H, *L. saucia*, dorsal view; I, *Chorizagrotis auxiliaris*, lateral view; J, *Euxoa messoria*, lateral view; K, *Agrotis ypsilon*, lateral view; L, *Lycophotia infecta*, lateral view, green phase; M, *L. infecta*, lateral view, brown phase; N, *L. saucia*, lateral view. × 1.3.



LARVAE OF SPECIES OF POLIA AND PRODENIA

A, *Polia renigera*, dorsal view; B, *P. meditata*, dorsal view; C, *P. legitima*, dorsal view; D, *Prodenia ornithogalli*, dorsal view; E, *P. dolichos*, dorsal view, light phase; F, *P. dolichos*, dorsal view, dark phase; G, *P. eridania*, dorsal view; H, *Polia renigera*, lateral view; I, *P. meditata*, lateral view; J, *P. legitima*, lateral view; K, *Prodenia ornithogalli*, lateral view; L, *P. eridania*, lateral view. × 1.3.



LARVAE OF SPECIES OF AGROTIS

A, *Agrotis c-nigrum*, dorsal view; B, *A. c-nigrum*, dorsal view, light phase; C, *A. c-nigrum*, dorsal view, dark phase; D, *A. badinodis*, dorsal view; E, *A. badinodis*, dorsal view, light phase; F, *A. unicolor*, dorsal view; G, *A. c-nigrum*, lateral view; H, *A. badinodis*, lateral view; I, *A. unicolor*, lateral view. × 1.3.

LARVAL STAGE

As recorded in Table 18, the larval stage in July-August requires about 4 weeks, while 5 to 7 weeks are required in August-September, with the majority completing the stage in about 5 weeks.

PUPAL STAGE

In addition to the periods given in Table 18, the pupal stages given in Table 20 have been recorded.

TABLE 20.—*Duration of pupal stage in Feltia annexa*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
June 12, 1914	June 25, 1914	13	82.5	July 24, 1916	Aug. 6, 1916	13	81.2
June 21, 1914	July 5, 1914	14	83.1	Aug. 15, 1916	Sept. 1, 1916	17	75.6
June 23, 1914	July 7, 1914	14	82.2	Aug. 17, 1913	Sept. 1, 1913	15	78.5
June 24, 1914	July 8, 1914	14	82.1	Do	Sept. 2, 1913	16	79.2
June 28, 1914	July 12, 1914[1]	14	81.4	Aug. 18, 1913	do	15	79.0
June 29, 1914	July 13, 1914	14	82.4	Do	Sept. 3, 1913	16	79.3
July 1, 1914	do	12	82.7	Do	Sept. 4, 1913	17	79.5
Do	July 14, 1914	13	83.0	Aug. 19, 1913	do.[1]	16	79.2
July 2, 1914	July 15, 1914	13	83.3	Aug. 20, 1913	do	15	79.3
July 11, 1915	July 25, 1915[1]	14	80.8	Do	Sept. 5, 1913	16	79.3
July 10, 1915	do	15	81.1	Aug. 19, 1913	Sept. 6, 1913[1]	18	79.4
July 13, 1915	July 27, 1915	14	79.5	Aug. 20, 1913	do.[2]	17	79.5
July 12, 1915	July 28, 1915	16	80.0	Aug. 21, 1913	do	16	79.3
July 13, 1915	do	15	79.7	Aug. 22, 1913	Sept. 8, 1913[1]	17	79.8
Do	July 29, 1915[2]	16	79.9	Aug. 23, 1913	do.[1]	16	80.4
July 14, 1915	do	15	79.6	Do	Sept. 9, 1913	17	80.4
July 16, 1915	do	13	78.7	Aug. 24, 1914	Sept. 10, 1914	17	75.6
July 18, 1916	July 30, 1916	12	80.3	Aug. 28, 1914	Sept. 17, 1914	20	73.6
Do	July 31, 1916[1]	13	80.5	Sept. 29, 1913	Nov. 6, 1913	38	58.5
July 19, 1916	do	12	80.5	Sept. 30, 1913	do	37	58.1
Do	Aug. 1, 1916	13	80.5	Do	Nov. 13, 1913	44	56.6
July 20, 1916	Aug. 3, 1916	14	80.4	Oct. 1, 1913	do.[1]	43	56.4
July 22, 1916	Aug. 4, 1916	13	80.6				

[1] 2 individuals. [2] 3 individuals.

The pupal stage requires two weeks or slightly more in July, August, and the fore part of September. The prepupal stage is brief, occupying not more than 4 or 5 days. October 4 is about the earliest date of pupation which yields hibernating pupae, the moths emerging the same season in pupae formed previous to this date.

PARASITES AND PREDATORS

Of 21 larvae sent in by J. U. Gilmore from South Boston, Va., 9 produced flies determined as *Bonnettia compta* Fall. These had a puparial stage of 9 to 12 days in July. This species deposits a firm-walled, whitish egg similar to that of *Winthemia quadripustulata* Fab. and the puparium is smooth, dark brownish fuscous, dully shining, with minute transverse rugae, and is about 10 mm. long. A larva which emerged from a third-instar host larva and spun a brown cocoon produced *Microplitis feltiae* Mues. *Apanteles griffinii* Vier. has also been reared from larvae.

In 1921, 217 larvae were collected when nearly mature and reared singly in tin boxes with unsterilized field earth. Mortality was as follows:

Moths emerged		178
Parasitized		11
Insects:		
Bonnettia compta Fall	2 larvae.	
Disease:		
Metarrhizium anisopliae	3 larvae.	
Beauveria sp	5 (3 pupae, 2 larvae).	
Nematode:		
Mermis sp	1 larva.	
Died as larvae without apparent cause		17
Died as pupae		11

Larvae of *Calosoma sayi* Dej. were common in a field infested by this species and were able to kill full-grown larvae, seizing and stubbornly holding the victim until it ceased struggling, when the predator tore a hole in the body and quickly consumed the contents. They also dug a short distance into the soil and attacked pupae of *F. annexa*, thrusting the head entirely within the pupa in their voracity. Adults of the above species were also feeding on the cutworms and must have been particularly effective in destroying them, since larvae of this species lie on the surface or very shallowly buried. A beetle was observed to attack three larvae in quick succession, mangling them into a limp, pulpy mass in a remarkably short time. *Harpalus erythropus* Dej. was also found feeding on larvae, and a spider, determined as *Marpissa undata* DeG. by Shoemaker, was observed feeding on a moth of this species.

Jones (*40*) records *Enicospilus purgatus* Say and *Bonnettia compta* Fall. from larvae and states that *Helicobia helicis* Town. may have been parasitic. He also found a fungus, *Entomophthora virescens* Thaxter, infesting dead larvae. Muesebeck (*50*) lists this species among the hosts of *Meteorus vulgaris* Cress. and *M. laphygmae* Vier. The same writer (*49*) includes this species among the hosts of *Microplitis feltiae* Mues.

THE PALE-SIDED CUTWORM, FELTIA MALEFIDA GUENÉE

DISTRIBUTION

Feltia malefida occurs throughout the southern part of the United States and also in Cuba and Mexico, and has been reported from New York, New Jersey, and the District of Columbia, but larvae probably are not found or are quite scarce north of the latitude of the southern boundary of Virginia since they have never been found in the course of much collecting in Virginia, and only one larva and two moths have been taken at Clarksville during 10 years.

Larvae have been examined from Clarksville, Tenn., Quincy, Fla., Solitude and Baton Rouge, La., Uvalde and Victoria, Tex., Lerdo, Durango, and Estado de Michoacan, Mexico.

FOOD PLANTS

The known food plants include cabbage, clover, collard, corn, cotton, bean, onion, Johnson grass, pea, pepper, Portulaca, potato, salsify, tobacco, tomato, chickweed, and other weeds. This species was first reared from tobacco by D. C. Parman, at Quincy, Fla.

Habits and Importance

Riley (*54*) states that the larva of this species is usually found associated with that of *Feltia annexa* and that it lives almost exclusively in a tunnel several inches long into which it drags plants and leaves for diurnal feeding. The larva does not seem to be common in Florida, and Jones (*40*) found that it comprised but 2.5 per cent of the cutworms found injuring plants in Louisiana during 1915, 1916, and 1917; but the larvae are apparently more abundant at Uvalde, Tex.

Seasonal History

The following outline of the seasonal history of this species is derived from data from Texas, Louisiana, and Florida, chiefly from adults and larvae received from D. C. Parman, of Uvalde, Tex.

There seem to be four broods in this species. The winter is passed in the pupal stage and moths begin to emerge the last of January and continue to emerge until the latter part of March. The resulting larvae produce moths which begin to emerge about the middle of May. The third-brood moths begin to appear the latter part of July, and at least the earlier emerging members of this brood produce an additional brood of moths whose progeny pupate before cold weather.

Description of Stages

ADULT (PL. 4, F)

Thorax light gray sometimes tinged with brownish, collar blackish with a distinct black line, forewings concolorous with thorax, with the base and costal margin strongly infuscated, the orbicular spot much elongated, and the claviform spot, below this, large and black. Hind wings white, with the veins and a slight margin infuscated. Expanse from about 1½ to 1¾ inches.

EGG

The egg is white, circular in outline, broadly bluntly subconical in profile, 0.62 to 0.69 mm. broad, and 0.46 to 0.55 mm. high, with about 40 to 55 moderately strong, slightly sinuate ribs, the longer of which reach the micropylar area, and many indistinct transverse lines, the micropyle elevated. These eggs, so far as observed, do not develop a belt and micropylar splotch of color.

LARVA

This larva has the head coloration of the reticulated type shown in Figure 4, B; the skin granules are very small, but slightly convex, and are set contiguously like the blocks in a pavement; setigerous tubercle I of the abdomen is usually nearly or quite as large as tubercle II; the spiracles are set in the pale ventral coloration; and each anterior proleg in the mature larva bears about twelve crochets. This combination of characters will serve to distinguish this larva from all others.

First instar.—Head 0.31 mm. broad. Body about 3.6 mm. long and 0.55 mm. broad; broadest through abdominal segments 1 to 3; set rather closely with small rounded granules; color pale, with more or less ferruginous, venter pale, with the usual pale lines; cervical and anal shields fuscous. Head shield black. Setigerous tubercles, especially dorsally, showing a tendency to become longitudinal, I, II, and III of about equal size, IV distinctly smaller and all but touching the spiracle, V about equalling IV, all fuscous, their setae brown, long, and capitate, a shorter seta on tubercle IV. Functional prolegs on abdominal segments 4, 5, 6, and 10, the crochets in a hood. Legs dark.

Second instar.—Head 0.48 mm. broad. Body about 6.7 mm. long and 1 mm. broad; of nearly uniform width throughout; skin set rather closely with minute rounded granules; general color a mixture of white and bright ferruginous. Head shield smoky brownish, the freckled reticulation (a mixture) dark fuscous, seta E^1 clavate, F^1 capitate. Cervical shield brownish, with dark flecks, anal shield similar. Setigerous tubercles not prominent, of about equal size, their setae brownish, capitate. Functional prolegs on abdominal segments 4, 5, 6, and 10.

Third instar.—Head 0.96 mm. broad. Body about 6.5 mm. long and 1.5 mm. broad; of about uniform width throughout; skin set very closely with minute rounded granules; general color grayish overlaid with fuscous and bright ferruginous splotches. Head shield brown, the reticulation replaced by isolated flecks of color disposed dorsally. Cervical shield concolorous with adjacent parts. Setigerous tubercles large, brown, of about equal size, their setae brown and very slightly enlarged apically. Spiracles dark, protuberant. Functional prolegs on abdominal segments 4, 5, 6, and 10.

Fourth instar.—Head 1.4 to 1.5 mm. broad. Body about 16 mm. long and 2.5 mm. broad; of practically uniform width throughout; skin set very closely with distinct, uniform, rounded, chitinous granules; general color grayish or white, overlaid, especially on the dorsum posteriorly, with splotches of fuscous and ferruginous, the spiracles nearly included in the pale ventral coloration, the usual pale lines faintly indicated. Ground color of head shield grayish, the median arcs strong, the reticulation replaced by fuscous flecks disposed dorsally, none of the setae capitate. Setigerous tubercle II of abdomen distinctly larger than I but not twice as large, III equal to I, IV as large as II, their setae scarcely capitate. Spiracles black, protuberant, with an encircling subcutaneous fuscous ring. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10.

Fifth instar.—Head 2.1 to 2.3 mm. broad. Body about 25 mm. long and 3.2 mm. broad; of practically uniform width throughout; skin set very closely with slightly convex contiguous granules; general color pale grayish overlaid dorsally with fuscous and ferruginous, the spiracles almost included in the pale ventral coloration, tubercle III of the abdomen set in the white splotch characteristic of the species, the usual pale lines faintly indicated. Head shield ground color pale grayish, the submedian arcs strong, fuscous, strongly divergent above, the reticulation sparse. Anal shield pale. Cervical shield pale, heavily infuscated. Spiracles black, oval, without a subcutaneous encircling fuscous ring. Setigerous tubercle I of abdomen distinctly less than II, III equal to I, IV somewhat larger than II, their setae not capitate.

Sixth instar (pl. 6, F, G, L).—Head 3 to 3.4 mm. broad. Body about 35 to 40 mm. long and 6 mm. broad, and 6 mm. or more thick, very heavy bodied; the metathorax and abdominal segments of practically uniform width throughout, when extended, the abdomen not narrowing until very near the posterior extremity; skin set with very fine granules, less than one-fiftieth of a millimeter broad, which are but slightly convex and set contiguously; dorsum and most of the supraspiracular area nearly unicolorous, the tint varying from light gray to dark fuscous, below, including the spiracles, pale with many white splotches; one peculiarity of the coloration is the concentration of the supraspiracular pair of lines into a conspicuous white spot about tubercle III of each abdominal segment, between which the white markings are nearly obsolete. Head shield ground color pale grayish or brownish, with fuscous submedian arcs and fuscous or ferruginous reticulation, reticulation more or less obsolete, especially above the base of the antennae; the adfrontal sutures terminating in the occipital foramen. Setigerous tubercles variable in size, I of abdomen usually about as large as II, III sometimes larger than II, IV largest, V sometimes larger than III. Spiracles black. Legs whitish tinged with pale brown apically. Prolegs pale, each anterior proleg with about 12 to 15 crochets.

Mouth parts: Mandibles of the ordinary type. Hypopharynx as in *Agrotis ypsilon*, the lingua occupying about one-third the length of the part, the blade of the maxillulae with about 25 short, flat, contiguous teeth having their tips broadly rounded or truncate. Labial palpi with the segments in the proportion of 23, 2, and 8.

Setae and punctures of head: SO^3 distinctly nearer to G^1 than to O^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 19 mm. long and 5.5 mm. broad, maxillary palpi visible, labrum emarginate, prespiracular callus present on prothorax, movably linked abdominal segments finely, closely punctured on anterior third, spiracles broad, directed laterally, cremaster without secondary spinules, spines remote at base, divergent, polished, with an enlarged, dull base but without a basal process, a coarsely obscurely rugulose area before the spines and a finely striate area beneath them.

LIFE HISTORY

TABLE 21.—*Length of generations in Feltia malefida*

Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
1916	1916	*Days*	° *F.*	1916	*Days*	° *F.*	1916	*Days*	° *F.*	*Days*	° *F.*
May 26	May 31	5	79.4	July 1	31	72.5	July 17	16	76.9	52	74.5
26	---do----	5	79.4	---do----	31	72.5	July 18	17	77.2	53	74.7
26	---do----	5	79.4	July 2	32	72.7	---do----	16	77.0	53	74.6
26	---do----	5	79.4	July 1	31	72.5	July 19	18	77.4	54	74.8
26	---do----	5	79.4	July 2	32	72.7	---do----	17	77.3	54	74.8
26	---do----	5	79.4	---do----	32	72.7	---do----	17	77.3	54	74.8
26	---do----	5	79.4	---do----	32	72.7	July 20	18	77.4	55	74.8
26	---do----	5	79.4	---do----	32	72.7	---do----	18	77.4	55	74.8
26	---do----	5	79.4	---do----	32	72.7	---do----	18	77.4	55	74.8
26	---do----	5	79.4	---do----	32	72.7	---do----	18	77.4	55	74.8
26	---do----	5	79.4	---do----	32	72.7	---do----	18	77.4	55	74.8
26	---do----	5	79.4	July 3	33	72.9	---do----	17	77.2	55	74.8
26	---do----	5	79.4	---do----	33	72.9	---do----	17	77.2	55	74.8
26	---do----	5	79.4	July 1	31	72.5	July 21	20	77.6	56	74.9
26	---do----	5	79.4	July 2	32	72.7	---do----	19	77.5	56	74.9
26	---do----	5	79.4	July 3	33	72.9	---do----	18	77.4	56	74.9
26	---do----	5	79.4	---do----	33	72.9	---do----	18	77.4	56	74.9
26	---do----	5	79.4	July 4	34	73.0	July 22	18	77.6	57	75.0
26	---do----	5	79.4	July 5	35	73.0	---do----	17	77.8	57	75.0
26	---do----	5	79.4	July 6[1]	36	73.2	---do----	16	77.8	57	75.0
July 27	July 31	4	81.1	Sept. 3	34	77.4	Oct. 4	31	65.9	69	72.4
27	---do----	4	81.1	Sept. 6	37	77.4	Oct. 5	29	64.8	70	72.4
27	---do----	4	81.1	Sept. 4	35	77.4	---do----	31	65.7	70	72.4

[1] Afternoon.

PREOVIPOSITION PERIOD

One moth emerged on the night of July 17, 1916, and two others emerged on the night of July 18. Infertile eggs were deposited on the night of July 21, but the first fertile eggs were obtained on the night of July 27, nine days after the appearance of the first pair.

EGG STAGE

TABLE 22.—*Duration of egg stage in Feltia malefida*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
May 26, 1916-----	May 31, 1916	5	79.4	June 4, 1916------	June 12, 1916	8	70.7
May 28, 1916-----	June 2, 1916	5	77.8	June 13, 1916-----	June 17, 1916	4	65.5
June 2, 1916------	June 10, 1916	8	71.9	July 27, 1916[1]----	July 31, 1916	4	81.1
June 3, 1916------	June 11, 1916	8	70.7	July 30, 1916-----	Aug. 3, 1916	4	80.5

[1] 2 lots.

LARVAL STAGE

Larvae at Clarksville have required about 4 or 5 weeks for the completion of their growth, as indicated in Table 21.

PUPAL STAGE

In addition to the pupal stages given in Table 21, those given in Table 23 have been recorded.

TABLE 23.—*Duration of pupal stage in Feltia malefida*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
May 15, 1913	June 2, 1913	18	71.5	Sept. 24, 1915	Oct. 31, 1915	37	62.4
May 25, 1913	June 16, 1913	22	73.8	Do	Nov. 6, 1915	43	62.0
June 7, 1913	July 1, 1913	24	79.0				

In May, June, and July the pupal stage requires about 16 to 24 days, while in September and October a month or more is required for the completion of the stage.

PARASITES

Sanderson (*55, p. 10*) records (*Glyptapanteles*) *Apanteles militaris* Walsh and *Meteorus vulgaris* Cress. as parasitic on the larva.

THE EUXOA GROUP

GENERAL CHARACTER OF LARVAE

This group includes the larvae of Porosagrotis, Euxoa, and Chorizagrotis. In these larvae the head shield is not reticulated as in Feltia, but bears close-set fuscous or light-brown flecks; tubercle II is about twice as large as tubercle I, usually three times as large in *Chorizagrotis auxiliaris;* and the skin is finely pavement-granulose. Their affinities seem to be with Feltia through Porosagrotis, as indicated below.

Feltia and Porosagrotis:
- P^a, A^a, and A^3 not in a straight line.
- P^2, P^1, and Adf^1 not in a straight line.

Euxoa and Chorizagrotis:
- P^a, A^a, and A^3 approximately in a straight line.
- P^2, P^1, and Adf^1 in a straight line.

Porosagrotis may be distinguished from Euxoa and Chorizagrotis by the characters indicated below.

Porosagrotis:
- Claw of legs without a basal tooth, or angulation.
- A^a decidedly nearer to A^2 than to P^2.
- P^2, P^1, and Adf^1 not in a straight line.
- P^a, A^a, and A^3 not approximately in a straight line.

Euxoa and Chorizagrotis:
- Claw of legs with a distinct, acutely angulate, basal tooth.
- A^a nearly or quite equidistant from A^2 and P^a.
- P^2, P^1, and Adf^1 approximately in a straight line.
- P^a, A^a, and A^3 approximately in a straight line.

There is very little evidence derived from the character of the larvae upon which to base the separation of Chorizagrotis from Euxoa. In Euxoa tubercle II is about twice as large as tubercle I, while in Chorizagrotis this tubercle is about three times as large as I, but this character is somewhat variable and would seem to be specific rather than generic. The pale brown flecks on the head shield of *Chorizagrotis auxiliaris* are duplicated in certain species of Euxoa which are not included here.

THE SPOTTED-LEGGED CUTWORM, POROSAGROTIS VETUSTA WLK. (POROSAGROTIS MURAENULA G. & R.)

DISTRIBUTION

Porosagrotis vetusta occurs along the Atlantic coast from Nova Scotia to Georgia, and also in Michigan. West of the Mississippi River the reported distribution includes Colorado, British Columbia, Washington, and Arizona. There is a considerable area in the interior of the United States from which the writer has seen no record of the occurrence of this species. Larvae have been examined from South Boston, Va., and Holland, Mich.

FOOD PLANTS AND HABITS

The list of known food plants includes bean, cabbage, cantaloupe, corn, cowpea, dandelion, dewberry, kale, lettuce, mullein, peach buds, parsley, spinach, tomato, turnip, and watermelon.

Chittenden (*14*) gives several instances of the abundance of this larva in the tobacco-growing regions of Virginia and North Carolina. One correspondent stated that it would have been impossible to grow tobacco or cotton in one of the years of especial prevalence of this cutworm; he found it impossible to get a stand of watermelons until the larvae had matured; and he noticed that they climbed dewberry vines sometimes a dozen or more to a vine, and devoured the buds and leaves, and that they treated young peach and other trees in a similar manner. Slingerland (*58*) also records the climbing habit and injury to peach buds in New York. J. U. Gilmore found the larvae common about mullein (*Verbascum thapsus*) in a sandy river-bottom pasture where as many as 47 larvae were taken about a single plant at a depth of from 1 to 3 inches in the soil.

SEASONAL HISTORY

The following outline of the seasonal history of this species has been prepared from data obtained from a large number of larvae sent by J. U. Gilmore, from South Boston, Va. There is apparently but one brood. Larvae in the last instar were collected the latter part of March, indicating that the winter is passed in the larval stage, and larvae continued active until May 1, 1918. It seems probable that there is a prepupal stage of varying length, such as occurs in *Euxoa messoria*, since the writer obtained moths from July until the latter part of September.

Chittenden (*14*) records that larvae were injurious until the weather became too cold for them to work in 1900; that they were common in Virginia March 22 and were also present in June, 1908;

that they were abundant in North Carolina in April and still destructive on May 18; and that moths were taken from May 20 to September 20, 1910. Slingerland (*58*) received nearly full-grown larvae early in May and states that moths are taken in Massachusetts in August and September and in New York in July and up to August 25. He considers that there is but a single brood and that the winter is passed in the larval stage. He found that a pupa formed July 23 produced a moth August 17, giving a pupal stage of 25 days.

Description of Stages

ADULT (PL. 4, C)

Forewings and thorax pale uniform ash gray; near the base of the apical third of the forewing a transverse venular series of small black dots, preceding distinct white dashes; hind wings white but slightly darkened marginally if at all. Expanse from slightly less to slightly more than 1½ inches. The writer has not seen eggs of this species.

LARVA

In this larva the dorsum is light gray; the head shield bears rather pale fuscous flecks; there are certain peculiarities in the relationships of the head setae and punctures as discussed on a previous page; and the basal portion of the leg claw is broadly rounded without a trace of angulation. The mature larva is further distinguished from those of Euxoa in that each anterior proleg in *vetusta* bears about 16 to 20 crochets, whereas in the other genus these crochets are about 9 to 14 in number.

Mature larva.—Head 3.2 mm. broad. Body about 40 mm. long and 7 mm. broad; tapering on posterior half; skin very finely pavement-granulose; color neither plumbeous dorsally as in *Euxoa bostoniensis* and ferruginous or reddish as in *E. ochrogaster* nor paler ferruginous as in *E. messoria* or *Chorizagrotis auxiliaris*, but a light gray, paler in the earlier instars, with traces of a middorsal line and pair of more or less fused supraspiracular lines white; ventrally, including the spiracles, the body is quite conspicuously splotched with white which extends to the base of the prolegs but without forming a distinct subspiracular band (this band is present in earlier instars). Head shield ground color pale brownish gray closely flecked with rather pale fuscous, flecks darker posteriorly, the submedian arcs represented by a fuscous shade, the adfrontal sutures terminating in the occipital foramen. Setigerous tubercles pale fuscous, II of abdomen slightly larger than I, III about equaling II, IV distinctly much larger, V about equaling IV. Cervical shield infuscated brownish with fuscous flecks, no tendency toward a concentration of the infuscation anteriorly. Prolegs pale, each proleg of the anterior pair with about 16 to 20 crochets. Legs pale, the basal portion of the claw broadly rounded without a trace of angulation (fig. 15, F).

Mouth parts: Mandibles of the ordinary type. Hypopharynx as in *A. ypsilon*, the lingua occupying about half the length of the part, blade of the maxillulae with about 25 flat, rather bluntly pointed teeth. Spinneret short and broad with a median apical notch. Segments of labial palpi in the proportion of 25, 2, and 10.

Setae and punctures of head: A^a decidedly nearer to A^2 than to A^3. A^a twice as near to A^2 as to P^a. SO^3 distinctly nearer to G^1 than to O^3. G^1 distinctly nearer to SO^3 than to O^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 17 mm. long and 5.5 mm. broad, maxillary palpi visible, labrum emarginate, prespiracular callus present on prothorax, abdominal segments with round punctures anteriorly, spiracles broad, directed laterally, cremaster without accessory spinules, spines rather short, divergent, set on an indefinite basal process, areas both anterior to and below the spines obscurely rugulose.

PARASITES

Chittenden (*14*) records a species of Apanteles and *Linnaemyia picta* Meig. from larvae of this species.

THE DRAB CUTWORM, EUXOA BOSTONIENSIS GRT.

DISTRIBUTION

The writer has examined larvae of this species from South Boston, Va., and has seen moths from North Carolina, Massachusetts, and New York. The species is also credited to Canada. Apparently this form is nearly or entirely confined to the States bordering on the Atlantic.

FOOD PLANTS

Tobacco is the only food plant recorded for this species, since, so far as known to the writer, it has not heretofore appeared in economic literature. Larvae were taken injuring tobacco at South Boston, Va., by J. U. Gilmore.

DESCRIPTION OF STAGES

ADULT (PL. 4, M)

Dark uniform gray, the orbicular and the reniform spots obsolete, a dark transverse line through the reniform spot, another subapically. Hind wings white in the male, black in the female. Expanse about 1.5 inches. The writer has not seen eggs of this species.

LARVA

In this species the entire body above the spiracles is of a nearly uniform drab color and the venter is unicolorous livid. There is practically no trace of the white subspiracular markings found in all the other species of Euxoa known to the writer. The head shield is flecked with very deep fuscous spots as shown in Figure 16, B.

Mature larva.—Head 3.5 mm. broad. Body about 43 mm. long and 7 mm. broad; of about uniform width throughout, the posterior extremity very blunt; skin set pavementlike with very small slightly convex granules; nearly uniform drab above the spiracles, somewhat paler below, with faint traces of a middorsal and pair of supraspiracular pale lines, no white band or line below the spiracles. Anal shield somewhat infuscated, flecked with fuscous. Cervical shield infuscated brown, flecked with fuscous. Head shield ground color grayish brown, with deep fuscous, nearly black spots arranged as shown in Figure 16, B, the submedian arcs present, adfrontal sutures reaching the occipital sinus. Setigerous tubercle II larger than I but not twice as large, III slightly larger than II, V distinctly larger than III, IV largest of all. Spiracles black. Legs pale brownish, the basal portion of the claw with a distinct angulation. Each anterior proleg with about 11 to 14 crochets.

Mouth parts: Mandibles of the ordinary type. Hypopharynx as in *A. ypsilon*, blade of the maxillulae with about 20 long, flat, acutely pointed teeth. Spinneret broad and short with a median apical notch. Labial palpi with the segments in the proportion of 24, 2, and 10.

Head setae and punctures: A^a somewhat nearer to P^a than to A^2. P^1 slightly nearer to Adf^1 than to Adf^2. P^a, A^a, and A^3 approximately in a straight line. The interspace A^2 to A^a slightly greater than P^1 to P^a. P^b about midway between P^1 and P^2. P^2, P^1, and Adf^1 approximately in a straight line. SO^3 distinctly nearer to G^1 than to O^3. G^1 slightly nearer to SO^3 than to O^3. G^a somewhat nearer to O^3 than to G^1. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 20 mm. long and 6.5 mm. broad, maxillary palpi visible, labrum not emarginate, prespiracular callus present on prothorax, punctures on movably linked abdominal segments small, round, spiracles broad, directed laterally, cremaster without accessory spinules, spines rather distant at their bases, which are slightly enlarged, and set on a distinct process the lateral margins of which are rather thin, areas anterior to and below the spines obscurely rugulose.

SEASONAL HISTORY

This is a one-brooded species. Two larvae received May 31, 1917, were mature early in July, pupated late in August, and produced moths the latter part of September. This species probably has a prolonged egg stage, the larvae hatching in late fall or early spring.

THE DARK-SIDED CUTWORM, EUXOA MESSORIA HARR.

DISTRIBUTION

Euxoa messoria occurs throughout the breadth of the United States and Canada as far south, at least, as northern Tennessee, which is the most southern record known to the writer, although it has been reported from Venezuela and may occur sparingly in the more southern States. Larvae have been examined from Mott and Dickinson, N. Dak.; Sioux City, Iowa; Washington, D. C.; South Boston, Va.; Clarksville, Tenn.; and California.

FOOD PLANTS

Larvae have been recorded as feeding upon apple leaves, cabbage, clover, corn, flowering plants and shrubs, grape, onion, peach, pea, potato, radish, strawberry plants, sugar beet, sweet potato, tobacco, and turnip.

FOOD HABITS AND LARVAL HABITS

The climbing habit is particularly well developed in this species, which has been recorded several times as highly destructive to orchards and flowering shrubs. An especially full account is given by Riley (*53*), based on the observations of a correspondent, a Mr. Cochran, in Illinois, who states that the larva early in the evening moves swiftly from limb to limb, selecting first the blossom buds and, after these are gone, the leaf buds. Seventy-five larvae were taken from a single 6-year-old fruit tree in one evening, and on the ensuing evening they were nearly as numerous as before. The correspondent goes on to state that frequently 50 to 75 per cent of the trees planted on sandy ground were killed and that there was not an orchard on the sands of Michigan, the light timber openings of Indiana, or the sandy ridges of Illinois that had not suffered greatly, many orchards being ruined by the depredations of this cutworm. The larvae have also come into prominence on several occasions through their ravages in onion fields, and they have also done especially conspicuous damage in vineyards in California and in sweet-potato fields in New Jersey.

In the tobacco fields about Clarksville, Tenn., the larvae continue their activity at a period when most species have finished feeding and are one of the fairly common species found. The tobacco plants are usually cut off near the surface of the ground, but later in the year the larvae usually content themselves with cutting off leaves, nibbling leaves lying on the ground, and occasionally gnawing into the stems of the plants. During the day most of the larvae lie within one-half inch of the surface beneath a little heap of earth, but a few may occupy tunnels with the opening near the plant attacked.

The moth of this species oviposits almost exclusively in cultivated fields. The winter is passed in the egg stage, allowing time for a crop of wild plants to develop before the larvae hatch. The writer has taken a few larvae in worn-out clover fields where the moth had apparently been attracted to the bare spots. When tracts of timber are cleared up and the resulting fields are cultivated for two or three years they become especially subject to infestation, although severe infestation is by no means confined to such fields.

Seasonal History

Larvae begin hatching the last of January and continue hatching until the latter part of March. They begin to enter the soil for pupation the last of May and by June 10 all but a few stragglers have entered the soil. After a prepupal stage of 10 days to 10 weeks, the usual period being about a month or less, the larvae begin pupating. Pupation occurs from the fore part of June to about the 1st of September. Moths begin to emerge early in July and continue to emerge in numbers until early in September, stragglers extending the period of emergence until about the middle of October. Eggs deposited in the fall produce larvae the following spring.

Forbes (*28*) states that this species is single brooded, the larvae being most abundant in May and disappearing by the middle of June. An occasional moth occurs the latter part of June, although the main body appears in July and the adults are most abundant up to about September 20. Gibson (*33*) records that the larvae often occur in large numbers in the eastern Provinces of Canada in May and June and that the moths are on the wing in August and September and even as late as October 5. Riley (*53*) has found that moths occur through the months of July and August in Missouri.

Description of Stages

ADULT (PL. 4, K)

Dark ash gray tinged with shades varying from yellowish to reddish brown, with distinct dark transverse lines on the forewings, one of which passes through the reniform spot. The character of the typical markings is indicated in the illustration. This species in some cases approaches *Euxoa tessellata* in appearance, but the differences between typical examples of the two will be readily noted in an examination of the figures. Expanse, 1.25 to 1.60 inches.

EGG

Yellowish white, circular in outline, 0.62 mm. broad, and 0.43 mm. high, with about 45 heavy, slightly elevated ribs, which are nearly obsolete and more or less irregular in their course, and no transverse lines. The egg becomes iridescent, but no belt or micropylar splotch of color is developed, and after about two weeks it becomes dark colored owing to the color of the larva, which now lies apparently fully developed but quiescent within the eggshell. The eggs are deposited almost exclusively in cultivated fields, and the long egg stage allows sufficient time for the development of vegetation in plowed fields before the larvae hatch.

LARVA

The dull ferruginous or brownish dorsum, the dark fuscous flecks with which the head shield is marked, and the presence of a prominent white subspiracular band will serve to distinguish this species from all except *Euxoa tessellata,* and the characters in which these two larvae differ are discussed under *tessellata.* The claw of the legs is provided with a distinct basal tooth. (Fig. 15, E.)

First instar.—Head 0.27 to 0.30 mm. broad. Body about 2.3 mm. long and 0.43 mm. broad; set closely both dorsally and ventrally with large, strongly elevated fuscous papillae; color pale, more or less splotched and tinged with ferruginous especially in the supraspiracular area, the middorsal and a pair of supraspiracular lines indicated, pale, a broad pale band including the spiracles in its upper margin. Anal shield dark fuscous, distinctly emarginate anteriorly. Cervical shield dark fuscous. Head shield dark fuscous. Setigerous tubercles small, inconspicuous, all of about equal size, their setae extremely short, stout, and capitate and about one-eighth as long as an abdominal segment. Spiracles brownish, circular, their margins crenulated. Legs dark fuscous. Functional prolegs on abdominal segments 5, 6, and 10 slender, their crochets set in a hood.

Second instar.—Head 0.43 mm. broad. Body about 3.8 mm. long and 0.72 mm. broad; of about equal width throughout but tapering slightly posteriorly; skin set closely with rounded granules; color pale mingled with ferruginous, darker in the supraspiracular area, and with middorsal line, supraspiracular lines, and a band below the spiracles white, beneath pale marked with ferruginous. Head shield dark fuscous. Tubercles inconspicuous, fuscous, their setae brown, capitate, about one-sixth as long as an abdominal segment. Spiracles brown, their margins minutely crenulated.

Third instar.—Head 0.69 mm. broad. Body about 6 to 9 mm. long and 1.3 mm. broad; of nearly equal width throughout but tapering slightly posteriorly; skin set dorsally and ventrally with slightly isolated rounded granules; color a mixture of white and ferruginous, darker in the supraspiracular area, below the spiracles a broad white band including the spiracles in its upper margin, beneath white marked with ferruginous. Cervical shield brown with fuscous flecks as in the mature larva. Anal shield brown with fuscous dots. Head shield ground color brown with close-set dark fuscous flecks. Setigerous tubercles inconspicuous, fuscous, apparently of about equal size, their setae brown, somewhat capitate, about one-fifth as long as an abdominal segment. Spiracles round, fuscous.

Fourth instar.—Head 1.2 to 1.5 mm. broad. Body about 10 to 20 mm. long and 2 mm. broad; tapering on posterior half; skin set closely with minute subconical granules, dorsal area bright ferruginous, supraspiracular band broad, dark fuscous, including tubercle II in its upper margin, the two submedian pale lines forming an indefinite band, a distinct white band below the spiracles. Cervical and anal shields brown with characteristic fuscous flecks. Head shield ground color pale brownish with dark fuscous flecks. Setigerous tubercle II about twice as large as I, IV somewhat larger than II, III and V somewhat smaller than I. Spiracles black.

Fifth instar.—Head 2.2 to 2.3 mm. broad. Body about 30 mm. long and 4.5 mm. broad; tapering on posterior half; skin set rather closely both dorsally and laterally with distinct, minute, subconical chitinous granules; general color pale brownish or grayish, the dorsum faintly ferruginous, a distinct white band below the spiracles, beneath very pale, the dark setigerous tubercles contrasting strongly. Head shield ground color very pale brownish gray or whitish, a pale fuscous shade representing the submedian arcs, the remaining coloration in the form of distinct, isolated, dark fuscous flecks. Tubercle II scarcely larger than I, III equal to II, IV distinctly larger. Spiracles black. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10.

Sixth instar (pl. 7, B, J).—Head 3.2 mm. broad. Body about 30 to 37 mm. long and 5 mm. broad; tapering gently posteriorly; skin set with minute, convex, contiguous granules; general color dark grayish, the dorsum brownish or ferruginous and sometimes distinctly reddish, especially posteriorly, middorsal pale line broad, somewhat broken and broadly demarked with fuscous, from subdorsally to the spiracles a fuscous band bearing the usual pair of submedian pale lines, below the spiracles a distinct white band, beneath pale. Cervical shield infuscated brownish, shining, with a few fuscous flecks. Ground color of head shield grayish or whitish overlaid with close-set, small, dark fuscous flecks (fig. 16, D) which are usually evidently composite in character; lines of flecks posterior to the ocelli usually paler, but little infuscation dorsolaterally, the adfrontal sutures ending in the occipital sinus. Tubercle II of abdomen distinctly larger than I, III about as large as II, IV much larger. Spiracles black. Legs brownish gray, the claw with an acutely angulate basal tooth. Each anterior proleg with about 9 to 14 crochets.

Mouth parts: Mandibles of ordinary type. Hypopharynx as in *A. ypsilon*, the blade of the maxillulae with about 25 to 30 coarse, contiguous, flat, acutely pointed teeth. Spinneret short and broad with a median apical notch. Labial palpi with segments in the proportion of 12, 1, and 4.

Setae and punctures of head: P^a, A^a, and A^3 approximately in a straight line. P^1, P^2, and Adf^1 approximately in a straight line. SO^a quite variable in relation to SO^2 and SO^3. SO^3 decidedly nearer to G^1 than to O^3. G^1 distinctly nearer to SO^3 than to O^3. G^a somewhat nearer to O^3 than to G^1. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa (fig. 19, E) about 117 mm. long and 6 mm. broad, maxillary palpi visible, labrum not emarginate, callus present on prothorax before the mesothoracic spiracles, punctures on movably linked abdominal segments small, round, spiracles broad, directed laterally, cremaster with two pairs of straight accessory spinules, spines short, weak, convergent at tips and set on the tip of the abdomen without a basal process, areas both anterior to and below the spines smooth.

Life History

EGG STAGE

The egg stage in this species is not sharply defined, since eggs deposited the same night may continue to hatch over a considerable period. Thus eggs deposited on the night of August 31, 1916, began hatching January 29 and larvae continued to emerge at intervals until March 23. Also eggs deposited on the night of September 2 began hatching February 25 and did not all hatch until March 17. These eggs were deposited in glass tubes stoppered with absorbent cotton and were kept outdoors in an open place where sunlight had access to them much of the day. Fully developed larvae were present September 12 in the eggs deposited August 31. These larvae were entirely quiescent when removed from the eggshell, although the blood could be seen circulating and the parts seemed to be fully chitinized.

This egg stage would seem to be rather a disadvantage to the species since it exposes the young larva to the struggle for existence at what would seem to be a particularly inhospitable season. Possibly in more northern latitudes, where the metropolis of the species is located, the egg stage occupies the entire winter, giving the species the advantage of a cold-resistant, inconspicuous, quiescent stage in the time least fitted for activity. It may be possible that this unfavorable midwinter hatching is one of the limiting factors in the southern distribution of the species.

LARVAL STAGE

Larvae which hatched on the night of February 25, 1917, were in the fifth instar April 26 and were ready to enter the soil the latter part of May, giving an active larval period of about 3 months. The prepupal stage requires 2 months or more in some instances but the usual period is within a month. Thus about 4 or 5 months are spent in the larval stage.

PUPAL STAGE

TABLE 24.—*Duration of pupal stage in Euxoa messoria*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
June 15, 1915	July 10, 1915	25	75.7	July 11, 1917	Aug. 6, 1917	26	75.8
June 26, 1916	July 16, 1916	20	76.9	July 20, 1916	Aug. 9, 1916	20	80.2
June 29, 1916	July 18, 1916	19	77.5	July 19, 1917	Aug. 12, 1917	24	77.0
June 24, 1917	July 22, 1917	28	75.6	July 25, 1914	Aug. 14, 1914	20	80.7
June 26, 1917	July 23, 1917	27	75.2	July 28, 1916 [2]	Aug. 16, 1916	20	80.2
June 28, 1917	do	25	74.9	July 24, 1917	Aug. 16, 1917	23	76.4
June 26, 1917	July 24, 1917	28	75.4	July 26, 1914	Aug. 17, 1914	22	79.8
July 1, 1917	do	23	71.5	July 27, 1916	Aug. 17, 1916	21	80.4
June 27, 1917	do	27	75.4	July 28, 1916	do	20	80.4
July 4, 1916	July 25, 1916	21	77.8	July 29, 1916	Aug. 19, 1916	21	80.6
July 2, 1916	do	23	77.8	July 30, 1916	Aug. 20, 1916	21	80.6
June 27, 1916	do	29	78.0	Aug. 3, 1916 [2]	Aug. 22, 1916	20	80.5
June 30, 1917	July 26, 1917	26	72.2	Aug. 4, 1916	Aug. 24, 1916	20	79.5
July 9, 1914	July 27, 1914	18	84.1	Aug. 12, 1914	Sept. 1, 1914	20	79.2
July 6, 1916	July 28, 1916	22	78.4	Aug. 10, 1916	Sept. 2, 1916	23	76.4
July 7, 1916	do	21	78.6	Do.[1]	Sept. 3, 1916 [1]	24	76.3
June 11, 1918	July 28, 1918	47	69.6	Aug. 8, 1917	Sept. 4, 1917	27	71.9
July 9, 1916	July 29, 1916	20	79.5	Aug. 11, 1916	Sept. 5, 1916	25	76.1
July 10, 1916	July 30, 1916	20	79.8	Aug. 13, 1915	Sept. 10, 1915	28	74.2
July 9, 1916	do	21	79.6	Aug. 13, 1917	Sept. 10, 1917	28	73.2
July 10, 1917	Aug. 1, 1917	22	75.1	Aug. 14, 1917	Sept. 12, 1917	29	72.1
July 13, 1916	Aug. 4, 1916	22	80.5	July 25, 1917	Sept. 15, 1917	21	76.5
July 13, 1917	Aug. 5, 1917	23	76.2	Aug. 19, 1917	Sept. 18, 1917	30	70.5
July 18, 1916 [1]	Aug. 6, 1916 [1]	19	80.6	Aug. 28, 1916	Sept. 25, 1916	28	68.0

[1] 2 individuals. [2] Forenoon.

PARASITES AND PREDATORS

Of 35 larvae collected June 1, 1919, 8 were parasitized by a fly determined by Aldrich as *Sarcophaga cimbicis* Town., or *latisterna* Pk., and 7 were apparently killed by a fungus. The writer has also reared *Bonnettia compta* Fall. from larvae. There are several larvae in the National Museum collection which bear a fungous growth resembling Isaria.

Poecilus chalcites Say was observed feeding on a larva June 8, 1917.

Coquillett (*19*) records *Bonnettia compta* Fall. and *Aphria ocypterata* Town. as parasites.

THE STRIPED CUTWORM, EUXOA TESSELLATA HARR.

DISTRIBUTION

Euxoa tessellata occurs throughout the east-and-west breadth of the United States north of the latitude of the Ohio River and Virginia, and farther south in the Rocky Mountains, but seems especially prevalent in the northeastern States. It also is widely distributed in Canada. Larvae have been examined from Dickinson and Rugby, N. Dak., East Lansing, Mich., Sioux City, Iowa, and College Park, Md.

FOOD PLANTS AND FOOD HABITS

Larvae have been recorded as feeding upon apple leaves, bean, beet, cabbage, celery, cherry, clover, corn, cucumber, flax, grass, flowering plants, lettuce, melon, onion, parsnip, pear, plum, Polygonum, potato, radish, Rumex, squash, tobacco, and tomato.

Fitch (*24*) states that larvae cut off corn about half an inch above the surface of the ground and draw the severed plants into the soil for diurnal feeding, usually lying rather shallowly buried in the soil. He found them especially fond of tobacco, records extensive damage to flax in New York, and considers the species to be especially injurious to gardens and to corn. Forbes (*28*) has not found the species especially prominent as a corn pest in Illinois. The larva has also been recorded as climbing fruit trees to feed upon the buds.

Seasonal History and Life History

It will be noted that the following seasonal history of *E. tessellata* differs from that of *E. messoria* more than might be expected in two such closely related species. The writer is dependent upon the authorities quoted below for his knowledge of the history of this species. A larva from Sioux City, Iowa, produced a moth at Clarksville, Tenn., May 7, 1918.

Fitch (*24*) gave the first and most detailed account of the seasonal history of this species and applied to it the common name by which the species is now known. He states that the eggs are dropped at the surface of the ground around the roots of grass and other herbage and that the larvae become about half grown by the arrival of cold weather and enter the soil to a depth of 3 or 4 inches, where they hibernate. When the warmth of spring returns the larvae again become active and are injurious in late May and early June, all larvae having disappeared by the end of June. Moths began to appear on July 6, 1862, and were numerous by July 10.

Forbes (*28*) states that the species is one-brooded and that the larvae are most destructive the latter part of May and in early June, the moths appearing in greatest numbers early in July. He states that moths have been taken in Iowa from early June to the beginning of August and in Canada during the latter part of July and the whole of August. Gibson (*33*) states that the species is apparently one-brooded. He found larvae injurious in the eastern Provinces of Canada in June, and moths were collected commonly in July and in smaller numbers in August. The length of the pupal stage ranged in June and July, 1912, from 16 to 22 days.

Description of Stages

ADULT (PL. 4, L)

Gray or brownish gray, with dark transverse lines on the forewings as shown in the figure, the orbicular and reniform spots, in well-marked specimens, connected and bordered by blackish. The hind wings are white with more or less marginal infuscation. This species sometimes resembles examples of *E. messoria*, in which the cell between the orbicular and reniform spots become somewhat infuscated. Expanse from slightly over 1 inch to nearly 1½ inches. The writer has seen no eggs of this species.

LARVA

This larva is very closely related to *Euxoa messoria* but differs from that species in the coloration of the head shield as indicated in Figure 16, C, D. It will be noted that the dorso-lateral region of the head shield is more intensely infuscated in *tessellata;* that the composite character of the dark fuscous flecks is less marked in this species; and that the markings centering about the ocelli are of a more stripelike character in *tessellata* than in *messoria*. The writer has examined only five specimens of this species, but these were from four widely separated localities and all of the larvae agree closely in the above characters.

Mature larva.—Head 3.2 mm. broad. Body about 32 mm. long and 5.5 mm. broad; tapering from about the metathorax posteriorly; skin set with very fine pavement granules; dorsum dull ferruginous, a middorsal and pair of supraspiracular pale lines present, a white subspiracular stripe, venter including prolegs uniform pale. Head shield ground color pale brownish gray with coloration as shown in Figure 16, C, the adfrontal sutures terminating in the occipital sinus. Tubercle II distinctly larger than I, II and III of about equal size, IV distinctly largest. Spiracles black. Claw of legs with a distinct, acutely angulate basal tooth. Each anterior proleg with about 12 crochets.

Mouth parts: Mandibles of ordinary type. Hypopharynx as in *A. ypsilon*, lingua occupying about one-third the length of the part, blade of maxillulae with about 25 broad, flat teeth. Other details indeterminable in the material at hand.

Setae and punctures of head: Relations of frontal and adfrontal setae not determinable in the material at hand. P^a, A^a and A^2 in a straight line. P^b approximately equidistant from P^1 and P^2. O^2 somewhat nearer to L^1 than to A^3. O^2 distinctly nearer to A^3 than to O^1. SO^a nearer to SO^2 than to SO^3. SO^3 somewhat nearer to G^1 than to O^3. G^1 somewhat nearer to SO^3 than to O^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 12 to 17 mm. long and 5 to 6 mm. broad, maxillary palpi visible, labrum not emarginate, prespiracular callus present on prothorax, punctures on movably linked abdominal segments small, round, spiracles broad, directed laterally, cremaster usually with two pairs of minute straight accessory spinules, spines straight, slender, slightly divergent, set on a distinct process, areas both above and below the spines obscurely rugulose.

THE ARMY CUTWORM, (EUXOA) CHORIZAGROTIS AUXILIARIS GRT.

DISTRIBUTION

Chorizagrotis auxiliaris has not been reported from east of the Mississippi River or, apparently, from the States contiguous to the river on the west with the exception of Missouri and Iowa, but occurs throughout the remainder of the United States. It is especially injurious in the Rocky Mountains and adjacent areas both in the United States and Canada. Larvae have been examined from Mott and Dickinson, N. Dak., Geddes, S. Dak., New Castle, Colo., Sacramento, Calif., Uvalde, Tex., and Lerdo, Durango, Mexico.

FOOD PLANTS AND HABITS

The larva attacks a wide variety of plants, including alfalfa, apple, apricot, *Balsamorrhiza sagittata*, barley, beet, blackberry, bluegrass, cabbage, cactus, celery, cherry, clover, corn, currant, dandelion, flax, fruit trees, avens (*Geum triflorum*), gooseberry, prairie grasses, horseradish, larkspur, maple seedlings, mustard, oat, onion, pea, peach, potato, plum, prune, radish, raspberry, redtop, rhubarb, rye, strawberry, sugar beet, thistle, timothy, tomato, turnip, wheat, shepherd's purse, and various other weeds. Strickland (*68*) found that among the weeds stinkweed (*Thlaspi arvense*) and tansy mustard (*Sisymbrium incisum*) were especially attractive.

The larva normally feeds above the surface of the soil and appears periodically in enormous numbers, whereupon it may assume the army-worm habit. Strickland found larvae to the number of 100 or 150 to the square foot in some fields in southern Alberta, and Cooley and Parker (*17*) report a nearly state-wide infestation in Montana in 1915 during which at least 100,000 acres of grain, mostly winter wheat, were destroyed. Gillette (*34*) records this species as destructive to beets and alfalfa in Colorado.

Seasonal History

This is a single-brooded species in the North, as determined by the studies of Cooley (*16*) and Strickland (*68*). The winter is passed as about half-grown larvae which become mature and begin to enter the soil for pupation early in April, pupation taking place chiefly in early May. The moths emerge from June to August, the main emergence occurring early in July, and, after a remarkably long adult life, the moths deposit their eggs chiefly in September and the first half of October.

In the South the seasonal history has not been thoroughly established but seems to differ in some essentials from that recorded above as indicated by material received from Uvalde, Tex., through D. C. Parman. In the North the latest oviposition occurred about the middle of October, while in Texas, where the season should be about six weeks more advanced, moths were taken in large numbers in November and were still ovipositing freely. Larvae were taken in three instars in the following January and also in February and March. Mature larvae occurred the latter part of January and moths from these larvae began to appear in May. Moths were also collected in small numbers from the beginning of March and in April and May. The earlier of these may have been hibernated individuals.

Description of Stages

ADULT (PL. 4, D)

Three species have been described which, as shown by recent breeding work, are but color variations of this one species, two or more of these forms having been bred from the eggs of a single moth. This extreme variation renders it difficult to give a description by which the species may be readily determined. The figure in the plate represents the form with uniform bluish-gray forewings tinged with yellowish which has been known under the name of *agrestis* Grote. In *auxiliaris* Grote, in the narrow sense, the forewings have bright-yellow markings and the cell between the orbicular and reniform spots is filled with blackish as in *Euxoa tessellata*. The form described as *introferens* Grote is much the same as *auxiliaris* with the yellow of the markings less pronounced. Expanse 1.5 to 2 inches. This species is said to enter houses for the purpose of concealment in such numbers during periods of abundance that the moths become a serious pest.

EGG

The egg is white, circular in outline, considerably flattened in profile, 0.60 mm. broad and 0.43 mm. high, with the base and lower half smooth without ribs or lines, the upper half with about 18 very slender and but slightly elevated ribs and a few transverse lines forming a coarse reticulation, a single rosette about the micropyle. A few days after deposition the egg becomes entirely suffused with pale ferruginous, which is replaced by dull plumbeous some time before hatching. Moths of this species are said to deposit their eggs, by preference, in the soil of cultivated fields, placing them singly or a few together, according to Cooley (*16*), on the surface, beneath small clods, or slightly buried in loose soil.

LARVA

This larva has the head shield flecked with close-set, pale infuscated brown spots; the claws on the legs bear a very distinct basal tooth; setigerous tubercle II is usually distinctly more than twice as large as tubercle I; the dorsum is not reddish but brownish in color; the median third of the anterior portion of the cervical shield has a distinct infuscated area; and each anterior proleg has about 9 to 12 crochets. The only cutworms known to the writer having the head coloration of nearly the same shade as the above are *Euxoa ochrogaster* Guen., *E. scandens* Riley, and *Porosagrotis vetusta*. In *ochrogaster* the dorsum is decidedly reddish in color; the cervical shield lacks the infuscated area found in *agrestis*; and tubercle II is not so large as in *agrestis*. In *scandens* there is no dark area on the anterior margin of the cervical shield, setigerous tubercle II is scarcely twice as large as I; and each anterior proleg in the two larvae seen bears about 19 crochets. In *Porosagrotis vetusta* the dorsum is gray or brownish gray; the claws of the legs have the basal portion broadly rounded without a trace of a tooth; and the cervical shield has no infuscated area anteriorly.

First instar.—Head 0.24 to 0.30 mm. broad. Body about 2.7 mm. long and 0.34 mm. broad, tapering gradually from the prothorax posteriorly; set closely with rather coarse subconical granules; white; head shield black; cervical and anal shields dark fuscous; setigerous tubercles not conspicuous, conical, I to V about equal, fuscous, their setae short, strongly capitate, those on tubercles I to IV about one-third as long as an abdominal segment, the seta on V somewhat longer; spiracles pale, slightly protruding, their margins minutely crenulated; legs black; long slender prolegs on abdominal segments 5, 6, and 10.

Mature larva (pl. 7, A. I).—Head 3.2 mm. broad. Body about 40 mm. long and 5 mm. broad, tapering posteriorly from about the fourth abdominal segment; skin granules set contiguously like the blocks in a pavement and about one-fiftieth of a millimeter broad; general color pale grayish much splotched with white, the dorsum tinged with brownish and with an indistinct band of white splotches just below the spiracles; cervical shield infuscated brownish, the median third of the anterior margin with a prominent dark fuscous area; head shield ground color very pale brownish gray, submedian arcs sometimes absent, other markings in the form of pale infuscated brownish flecks (fig. 16, A) which may be somewhat darker on the posterior margin, the adfrontal sutures terminating in the occipital foramen; spiracles black; tubercle II usually three times as large as tubercle I, III distinctly smaller than II; prolegs grayish, anterior pair each with about 9 to 12 crochets; legs grayish, with a distinct, acutely angulate basal tooth (fig. 15, E).

Mouth parts: Mandibles of the ordinary type. Hypopharynx as in *A. ypsilon;* spinneret broad and short and with a median apical notch; labial palpi with segments in the proportion of 25, 3, and 6.

Head setae and punctures: P^1 equidistant from Adf^1 and Adf^2 or somewhat nearer Adf^1. P^a, A^a, and A^3 approximately in a straight line. P^b very slightly nearer to P^2 than to P^1. P^2, P^1, and Adf^1 approximately in a straight line. SO^3 distinctly nearer to G^1 than to O^3. G^a usually somewhat nearer to O^3 than to G^1. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 15 mm. long and 6 mm. broad; maxillary palpi visible, labrum somewhat emarginate, prespiracular callus present on prothorax, punctures on movably linked abdominal segments small, round, spiracles broad, directed laterally, cremaster set on the tip of the abdomen without a basal process, accessory spinules absent, spines polished, distant at bases, set on an enlarged, polished, basal portion, areas anterior to and below the spines nearly or quite smooth.

LIFE HISTORY

Eggs deposited November 6, 1915, hatched on the night of November 26, giving an egg stage of 20 days at that season, but Cooley (*16*) states that the length of the egg stage is from 9 to 21 days with 9 or 10 days the usual period. He ascribes the longer egg stage to lack of moisture. Larvae are said to be found from September to May, and the pupal stage requires about two months. This applies to the northern part of the range of this species.

Parasites and Predators

The writer has secured *Meteorus vulgaris* Cress. from larvae from Uvalde, Tex.

Johnson (*39*) records *Amblyteles subrufus* (Cress.) and (*Ichneumon*) *Amblyteles longulus* (Cress.) as parasitic on larvae and states that larvae are also very largely parasitized by a species of Copidosoma of which one or two thousand occur in each larva attacked. He also observed that chickens, ground squirrels, pigs, quail, meadow larks, bluebirds, and blue jays fed upon the larvae and states that "the flocks of blackbirds which constantly patrol the fields destroy immense numbers." Cooley (*16*) records blackbirds, robins, crows, meadow larks, and beetles of the genera Harpalus and Calosoma as enemies of the larvae and states that a fly, probably *Peleteria tessellata* Fab., was the most abundant parasite and attacked about 5 per cent of the larvae. Strickland (*68*) found about 28 per cent of the larvae parasitized by four species of Hymenoptera, *Apanteles laeviceps* Ashm., *Berecyntus bakeri* How. var. *euxoae*, and species of Meteorus and Amblyteles, and also bred *Phorichaeta sequax* Will. He records *Calosoma tepidum* Lec., adults and especially larvae, *Calosoma zimmermani*, small Carabidae, *Ammophila luctuosa* Smith, cicindelid beetles, ants, meadow larks, sparrows, poultry, hogs, and the common gopher as predacious on the larvae or adults. He also states that two diseases caused a high mortality. Aldrich (*1*) records the breeding of *Peleteria robusta* Wied. from this species by Kelly. Strickland (*71*) records the breeding of *Meteorus dimidiatus* Cress., *Apanteles laeviceps* Ashm., and *Amblyteles subfuscus* Cress. from larvae. Muesebeck (*50*) lists this species as a host of *Meteorus vulgaris* Cress. Snow (*65*) records the following parasites: *Berecyntus bakeri* How., *Apanteles laeviceps* Ashm., *Meteorus vulgaris* Cress., *Amblyteles nuncius* Cress., (*Habrabracon*) *Microbracon erucarum* Cush., Paranomalon sp. (?), Ernestia sp., *Anthrax alternata* Say, *Anthrax willistonii* Coq., Apiochaeta sp., and *Phorichaeta cinerosa* Coq. (?). He also records a digger wasp as parasitic on larvae. Corkins (*20*) records the following parasites: Copidosoma sp., *Amblyteles longula* Cress., Microgaster sp., and *Berecyntus bakeri* How.

THE GLASSY CUTWORM, SIDEMIA DEVASTATOR BRACE

Distribution

The range of this species includes the entire breadth of the United States and Canada, but in the more southern part of the United States the species is scarce or absent. Forbes (*28*) in Illinois and Gillette (*34*) in Iowa consider this species to be the most serious pest of its kind to corn and grass. Smith (*61*) has found it to be one of the most destructive of the field cutworms in New Jersey. Slingerland (*59*) in New York took 471 moths in six trap lights in 1889. Norman (*51*) states that this is by far the most common moth at St. Catherines, Ontario. Gibson (*33*) records that this species is common in all the Canadian Provinces from Nova Scotia to British Columbia. In the National Museum collection are moths from Williams, Ariz., which is the most southern record known to the writer. Garman (*32*) records the collection of a larva in Kentucky which was reared to the adult, and Riley (*53*) gives a similar record for Missouri. There is an old account (*73*), possibly erroneous, of the occurrence of this larva in a vegetable garden in Mississippi. There are several species of larvae which are not superficially distinguishable from the glassy cutworm, however, and there is no indication in the Mississippi record that the adult was reared. Snow (*64*) does not list the species as occurring in Kansas, and the writer has taken neither moths nor larvae in Tennessee or Virginia. Larvae have been examined from Sioux City, Iowa, and Fargo, N. Dak.

Food Plants and Habits

The known food plants include beet, barley grass (*Hordeum jubatum*), bluegrass, bean, cabbage, corn, *Elymus virginicus*, hollyhock, lettuce, meadow grasses, oats, peach seedlings, radish, strawberry plants, timothy, tobacco, and wheat. This is preeminently a sod-infesting species, and it is in fields following sod, and especially in low ground, that the larvae most often prove injurious. The larvae are more strictly subterranean in habits than any other species here treated. When bred in a clump of *Elymus virginicus* they cleared a space beneath the rather thick layer of surface rubbish and fed upon the roots and adjacent stems of the plants. Gibson (*33*) states that the larva feeds upon the roots and lower stems of various kinds of grasses and records injury by this species to young tobacco plants in Ontario. Webster and Mally (*81*) observed in Ohio that fully 35 per cent of a planting of seedling peaches set out in the spring on sod land, which had been plowed the previous fall, were cut off about 2 or 3 inches above the roots prior to June 5.

Seasonal History

The seasonal history may be summarized as follows: There is apparently but one brood. The winter is passed as small larvae, and these begin pupating in May, but continue abroad in destructive numbers until about the middle of June. Moths begin to emerge in small numbers about the 1st of June, emerge mainly in July and August, and continue on the wing into October. Eggs deposited by these moths produce the overwintering larvae.

Gillette (*34*) states that moths are abundant in Iowa and have been captured from June 11 to October 3, being most abundant during August. Most of the eggs, he states, are deposited after the 1st of August. Slingerland (*59*) took moths in trap lights from the latter part of May until the fore part of September, the main catch occurring in August. Gibson (*33*) records moths from late June until the middle of September and states that the eggs are deposited the latter part of the season and that the winter is spent as small larvae. Forbes (*26*, *28*) states that the species appears to be single-brooded and that the eggs are deposited the latter part of the season. He has found that the larvae are destructive in central Illinois in May and the first half of June and that these pupate in June or during the early part of July, although occasionally pupation takes place as late as August. Moths begin to appear in June, become very abundant in August, and are present until October.

Description of Stages

ADULT (PL. 4, A)

The writer's collection contains but one specimen of this variable species. The following description is by Smith (*60, p. 426*):

Luteous to ash, to blackish gray, markings black or blackish. A small basal streak, and another at hind margin near base. Basal half line usually distinct, geminate. T. a. line outwardly oblique, sometimes arcuate, curved between veins; distinctly geminate. T. p. line geminate, the included space paler; outwardly curved over all cell, thence inwardly oblique to margin, its course rather even; only slightly dentate on veins. S. t. line pale, sometimes more or less punctiform; tolerably even except at apex, where it bends abruptly inward; preceded by a series of dark or black sagittate spots, which are sometimes more or less confluent. A row of dark or black terminal lunules. A distinct median shade between ordinary spots, and then near to and parallel with t. p. line, sometimes connected with it by a dark shade opposite claviform. Claviform small, black ringed, sometimes with a dusky shade. Orbicular variable in size and form, dark ringed, sometimes with a yellowish suffusion. Reniform large, upright, centrally constricted, black ringed, annulate, with white or yellow scales. Secondaries fuscous or smoky, darkest outwardly; a distinct discal lunule. Beneath variable in shade, powdery, with variably distinct outer lines and discal spots. Expands, 35 to 46 millimetres=1.40 to 1.75 inches.

A common and widely distributed form, varying greatly in every respect, and yet retaining a peculiar habitus that to the student betrays the species at a glance. The eastern specimens are, as a rule, more sordid and more evenly gray, while specimens from the Pacific slope show more contrast in color and the maculation is more sharply defined. Occasionally a specimen is found that is blackish throughout and leaves the lines visible by their paler included spaces; and one specimen before me is blackish, except for the median space. The tuftings are not prominent, and the species shows a decided relationship to the *Luperina* group of the genus.

The writer has not seen the egg of this species. Brace (*5*) states that the eggs are deposited at the base of trees and near the ground and that the moths conceal themselves in the crevices of buildings or beneath the bark of trees and that they are sometimes very troublesome about candles in houses.

LARVA

In this larva the skin is unpigmented as in a white grub; the head is reddish; the paraclypeal sutures terminate in the occipital sinus; and the apical papilla on the basal joint of the labial palpi is conical and no longer than the second segment. *Agroperina lutosa* And. and *A. helva* Grote, owing to like peculiar habits, agree with *devastator* in the possession of most of those characters in which this species differs from most other cutworms. These two species of Agroperina have a coloration closely resembling *devastator;* the spatulate setae on the first segment of the maxillary palpi are as in that species; the leg claws show no trace of a basal tooth; and the arrangement of the head setae and punctures is much like that found in *devastator*. But the species of Agroperina have the adfrontal sutures terminating distinctly before reaching the occipital sinus and the papilla on the basal segment of the labial palpi is setiform and twice as long as the second segment.

The affinities of this species with the larva with which it is here associated are not close. It is here classed with the Euxoa group and the Feltia group because of the fact that the adfrontal sutures terminate in the occipital sinus, but this condition was very probably arrived at in *devastator* through a different line of descent from the line of the above groups. The spinneret is extremely long and slender in *devastator* while it is uniformly short and broad with an apical notch in the associated groups, and the head setae and punctures in *devastator* show a different arrangement from that found in the others.

The illustration (pl. 7, D) shows a larva of *Agroperina lutosa*, since material of *devastator* was not available for photographing, and it should be borne in mind that the contour of the body is not quite the same in the two species since *devastator* tapers slightly from the mesothorax posteriorly.

Mature larva.—Head 4.5 mm. broad. Body about 35 to 40 mm. long and 5.5 mm. broad; tapering slightly from the mesothorax posteriorly; skin showing obscure granules only under the compound microscope; coloration like a white grub, a translucent greenish white with a dark subcutaneous middorsal line. Cervical shield conspicuous, infuscated brown, puncture X nearly on the line connecting puncture Y with tubercle II^a. Anal shield large and decidedly infuscated. Head shield bright reddish brown showing only faint traces of arcs and reticulation, setae on first joint of maxillary palpi broad and spatulate (fig. 9, A), the adfrontal sutures terminating in the occipital sinus, which penetrates to nearly half the length of the head shield. Setigerous tubercles large, concolorous with the adjacent parts or slightly infuscated, apparently of about equal size and bearing rather stout, short, brown setae. Spiracles narrow and long, brown with black rims. Legs brown, the claws unusually long and sharp and broadly rounded basally without a trace of a basal tooth. Prolegs on abdominal segments 3, 4, 5, 6, and 10, all with about 12 crochets each. The number of crochets increases decidedly posteriorly in all the other species.

Mouth parts: Mandibles of peculiar structure. (Fig. 6, G.) Hypopharynx narrowly oval, broadest posteriorly, two and a half times as long as broad, the lingua occupying about one-third of the length, the premaxillulary area with numerous very short and stout spines, smaller spines on the lingua extending slightly into the gorge which is otherwise bare, maxillulae densely clothed with slender, rather short spines, blade very narrow, toothless. Spinneret six times as long as broad. (Fig. 10, Q.) Labial palpi with the segments in the proportion of 29, 4, and (?).

Setae and punctures of head: A^2 very slightly nearer to A^3 than to A^1. A^a twice as near to A^2 as to P^a. A^3 the width of the ocellus or more removed from ocellus II. P^1 somewhat nearer to Adf^2 than to adf^1. P^1 on or slightly below the level of Adf^2. P^2, P^1, and Adf^1 in a straight line. P^a, A^2, and A^a forming almost a right angle at A^2. P^a distinctly above the level of Adf^1. P^b, A^2, and A^1 not in a straight line. Adf^2 twice as near to P^1 as to P^2. Adf^a somewhat nearer to Adf^1 than to Adf^2. O^2 decidedly more than the width of the ocellus removed from ocellus I. O^a less than the ocellar width removed from ocellus VI, and about four or more times as near to VI as to O^3. O^1 to O^3 the shortest side of the triangle formed by the ocellar setae. SO^3 approximately equidistant from G^1 and O^3. G^1 distinctly nearer to O^3 than to SO^3. G^a somewhat nearer to G^1 than to O^3. G^1 decidedly nearer to G^a than to SO^3. Arrangements of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 18 mm. long and 5 mm. broad, maxillary palpi visible, labrum not emarginate, prespiracular callus absent on prothorax, punctures of movably linked abdominal segments small, round, spiracles very narrow, elongate, directed laterally, cremaster a strongly depressed appendage bearing apically four spines of practically equal size, metathoracic legs not visible on median line posterior to tips of wings.

LIFE HISTORY

The published data on the life history of this species are meager. Larvae received from Sioux City, Iowa, through the kindness of

C. N. Ainslie and collected about May 23, pupated the latter part of June and a moth emerged on July 9. Riley (*53*) records that a pupa formed June 19 produced the moth on July 7. Webster (*81*) observed in Ohio that a pupa formed June 12, 1899, produced the moth June 26. Gibson (*33*) has observed in Canada that larvae pupating May 19, 1906, produced moths July 19, two months later. Brace (*5*), in Connecticut, states that the moth deposits her eggs in the autumn at the base of trees and near the ground and that these eggs do not hatch until the following May, the larvae becoming mature about a month after hatching and the pupal stage having about an equal duration. As pointed out by Harris (*36*), the above statement with regard to the length of the egg stage is probably erroneous.

Parasites

The writer has obtained *Gonia frontosa* Say, as determined by Aldrich, from larvae from Sioux City, Iowa, and there are several larvae in the National Museum collection which bear strands of a fungus, apparently Isaria, growing from the head and prothorax.

Gillette (*34*) records that a large dipteron (Gonia sp.?) was an abundant parasite of the larvae in Iowa and states that *Lissonota americana* Cress. was the most common hymenopterous parasite. Coquillett (*19*) gives *Gonia capitata* DeG. as one of the parasites of this species, but Aldrich states in a letter that in a recent revision of the genus Gonia by Tothill this specimen falls in *G. aldrichi* Tot. and that it is one of the series mentioned as Gonia sp. by Gillette (*34*). Gibson (*33*) reports *Berecyntus bakeri* How. var. *gemma* Gir. as parasitic on the larva. There is also a record (*75, p. 151*) of the rearing of (*Ichneumon*) *Amblyteles jucundus* (Brullé) from this species, and Strickland (*70*) has reared *Meteorus dimidiatus* Cress. from larvae.

THE GREEN CUTWORM, LYCOPHOTIA INFECTA OCHS. (PERIDROMA INCIVIS GN.)

Distribution

This species is quite generally distributed over the United States east of North Dakota and Texas, but is probably most abundant in the South. West of these States it is reported only from California. It occurs also in Manitoba, and in South America as far south as Brazil. Larvae have been examined from Clarksville, Tenn., Palm Beach, Fla., and Mississippi.

Food Plants and Habits

The observed food plants include beets, bluegrass, clover, crab grass, Muhlenbergia, plantain, purslane, and tobacco. Tobacco is fed upon only incidentally and in rare instances, the normal food consisting of various grasses, for subsistence upon which the larva is provided with mandibles of much the same type as occurs among the army worms, and also with a coloration somewhat similar to theirs. The larva is a very voracious feeder.

Seasonal History

There are apparently three broods in this species (unless the moths taken from early in May to the middle of June represent the second brood, in which case there are four broods). The winter is passed in the pupal stage, and the writer has taken moths from early in May to about the middle of June. From eggs deposited June 10, 1910, moths were obtained July 20 to July 24. These represent the second brood. From eggs deposited July 24, 1910, third-brood moths emerged September 10 to 14. Eggs deposited September 21, 1910, produced larvae which were preparing to pupate November 15. The emergence of the second brood occurs from about the 1st of July to the middle of August, and the third brood makes its appearance about the middle of August and continues to emerge until in November, some moths continuing on the wing into December.

Forbes (*27*) reports that the species is apparently two-brooded in southern Illinois. Larvae taken in spring produced moths in June and July. The second brood of larvae were found in August and September and produced moths in October. Larvae collected in central Illinois July 14 and 26 and September 2 went into the winter in the pupal stage. The larvae taken in the spring were the progeny of first-brood moths, since the winter is passed in the pupal stage, and there are probably three broods in Illinois.

Description of Stages

ADULT (PL. 3, E)

Body and forewings gray flecked with black scales; a broad dark-brown mark on the collar; forewings bright brown apically; the reniform spot dark with a white center and margined with an inner line of white and an outer one of brown. Hind wings white narrowly margined with a dark shade. Expanse about 1½ inches.

EGG (PL. 5, B, C)

The egg is white, circular in outline, approximately semicircular in profile, 0.55 to 0.63 mm. broad and 0.43 to 0.49 mm. high, with from 34 to 40 straight slender ribs, the long and short ribs alternating irregularly, and many distinct transverse lines, and the micropyle is elevated with a crenulated margin. The second day after deposition a belt and micropylar splotch of pinkish or chocolate brown appear.

The eggs are deposited in batches of one or two hundred on blades of grass and tall plants, and one egg mass was found on a telephone wire. They are not covered with scales from the moth. One moth deposited a total of 673 eggs in two nights and another deposited 523 eggs in five days.

LARVA

This is the only larva included here in which the mandibles are toothless or bear only microscopic teeth. (Fig. 6, A, *a*.) The arrangement of the head setae, as indicated below, is distinctive; the epipharyngeal setae are long and slender instead of short and stout as in all the other species; and the papilla on the apex of the basal segment of the labial palpus is conical and does not exceed the second segment in length.

The character of the papilla on the basal segment of the labial palpi will distinguish this species from the species of Cirphis which it resembles in coloration, in the peculiar relationships of most of the head setae and punctures, and in the character of the mandibles, hypopharyngeal setae, and labral emargination. These resemblances are probably due to a closely similar mode of life rather than to any close relationship between *L. infecta* and the species of Cirphis.

Larvae of *L. infecta* give no evidence of close relationship with the larva of *L. saucia* except in the character of the spinneret; in fact, the two species might well be supposed to belong to distinct genera. Possibly dissimilarities in the mode of life of the two species of larvae have resulted in distinctive specializations which have not, as yet, had a marked effect on the character of the adults.

The general color of larvae of this species is extremely variable, all the various color phases occurring among the progeny reared from a single egg mass.

First instar.—Head 0.34 to 0.36 mm. broad. Body about 2.7 to 3.4 mm. long and 0.2 mm. broad; skin somewhat granulose ventrally and posteriorly on the dorsum; whitish to pale lemon yellow, with eight brownish longitudinal lines, one including setigerous tubercle II and one dorsad and ventrad of tubercle III, and a well-marked white line below the spiracles. Head shield pale uniform fuscous brown. Setigerous tubercles large, fuscous, longitudinal on the thorax, rounded on the abdomen, III largest on abdominal segments 1 to 4, their setae long, very slender, dark fuscous, and feebly capitate. Cervical shield fuscous brown, convex before, concave and rapidly narrowing posteriorly. Anal shield pale fuscous, U-shaped, opening posteriorly. Legs fuscous. Prolegs pale, claws and shields dark fuscous, functional on abdominal segments 3, 4, 5, 6, and 10. The larva moves with a strong looper gait.

Second instar.—Head 0.50 to 0.55 mm. broad. Body about 5 to 6.5 mm. long; greenish; with a middorsal longitudinal white line and four pairs of ferruginous and three pairs of alternating white lines, the supraspiracular ferruginous and subspiracular white lines most conspicuous and all growing more distinct posteriorly. Setigerous tubercles fuscous, their setae long, conspicuous. Head shield pale grayish, ocelli dark ferruginous. The larva in this instar walks with a decided looper gait.

Third instar.—Head 0.84 to 0.91 mm. broad. Body about 8 to 10 mm. long; skin smooth; green with seven longitudinal white lines alternating with eight fuscous lines, the fuscous supraspiracular and pale subspiracular lines most conspicuous; the subspiracular line may vary from white to sulphur yellow, becomes gradually ferruginous late in the instar, and is continuous even on the head shield. Cervical shield grayish with six light fuscous lines. Head shield ground color pale grayish with, usually, 6 to 10 fuscous lines formed by the fusing of the reticulation anteriorily, front darker. Setigerous tubercles very small, their setae fuscous. Legs and prolegs pale marked with fuscous, claws of prolegs yellow.

Fourth instar.—Head 1.2 mm. broad. Body about 13 to 16 mm. long; with about 10 fuscous lines, the middorsal pair prominent, coloration otherwise as in sixth instar. Mandibles with a variable number of microscopic teeth on the straight cutting margin.

Fifth instar.—Head 1.6 mm. broad. Body about 15 to 20 mm. long. Mandibles with margin straight and bearing a variable number of microscopic teeth. Other details as in sixth instar.

Sixth instar (pl. 7, G, L, M).—Head 2.6 to 2.8 mm. broad. Body about 16 to 28 mm. long and 5.5 mm. broad; abdominal segments of about equal width throughout, tapering slightly on posterior half; skin smooth; varies in general color from gray through yellowish ferruginous, olivaceous yellow, and bright green to dirty brown and is usually speckled with black. The following marks are usually present: Beneath the pale, sharply defined subspiracular band a dark tinge fading out below; on each segment excepting the prothorax a dorsal pair of round white dots set a little before the middle and near to the subdorsal margin and more or less margined with black; posterior to and outside these dots a velvety black splotch which may form a more or less connected subdorsal band; posterior to this black spot a pair of parallel longitudinal pale lines, the lower one of which may be continuous. Head shield ground color pale grayish, the reticulation fused anteriorly to form about four fuscous lines not including the submedian arcs, a narrow pure white band upon and posterior to the base of the antennae, the adfrontal sutures terminating very remote from the occipital foramen, front occupying but little more than one-third the height of the head shield on the median line. Cervical shield straight before, convex posteriorly, pale whitish sometimes tinged with blackish and with three pale lines. Setigerous tubercles minute, black. Spiracles white or yellowish with black rims.

Mouth parts: Mandibles with the cutting margin straight, toothless, color pale brown, black at the margins. (Fig. 6, A.) Hypopharynx suboval, broadest posteriorly, the lingua occupying about one-third the length of the part, as a whole, including the gorge, clothed with short, heavy spines, smaller on the anterior and posterior margins and tending to be arranged in transverse rows posteriorly, and extremely dense on the disk of the lingua, heavier spines in the premaxillulary area, the teeth on the blade of the maxillulae tending to be arranged in a double series, the outer consisting of 10 to 15 long, coarse, flat, bluntly pointed teeth which are isolated but for their broad bases. (Fig. 11, K.) Spinneret rather broad and short, the apex spinosely produced. Labial palpi with the segments in the proportion of 17, 5, and 9.

Setae and punctures of head: A^2 approximately twice as near to A^1 as to P^a. A^a slightly nearer to A^2 than to A^3. A^a distinctly nearer to A^2 than to P^a. P^1 decidedly nearer to Adf^2 than to Adf^1. P^1 distinctly above the level of Adf^2. P^a distinctly above the level of Adf^1. Interspaces A^2 to A^a and P^1 to P^a approximately equal. O^2 distinctly nearer to A^3 than to L^1. L^1 about three times as near to L^a as to O^2. SO^a nearly or quite directly anterior to SO^3 and about four times as near to SO^3 as to SO^2. SO^3 slightly nearer to G^1 than to O^3. G^1 somewhat nearer to O^3 than to SO^3. G^a distinctly nearer to G^1 than to O^2. G^1 decidedly nearer to G^a than to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA (FIG. 18, C, D)

Pupa about 16 mm. long and 5.5 mm. broad, maxillary palpi visible, labrum not emarginate, prespiracular callus absent on prothorax, movably linked abdominal segments with very fine round punctures anteriorly, spiracles rather broad, directed slightly posteriorly, cremaster without spinules, spines short, divergent, directed downward, the areas both anterior to and below the spines smooth.

LIFE HISTORY

TABLE 25.—*Length of generations in Lycophotia infecta*

Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
		Days	° F.		Days	° F.		Days	° F.	Days	° F.
June 10, 1910	June 14, 1910	4	66.9	July 7, 1910	23	77.5	July 20, 1910	13	77.9	40	76.6
Do	do	4	66.9	July 10, 1910	26	77.8	July 24, 1910	14	77.1	44	76.6
June 12, 1918	June 16, 1918	4	58.1	July 22, 1918	36	77.4	Aug. 2, 1918	11	78.7	51	76.2
Do	do	4	58.1	do	36	77.4	Aug. 4, 1918	13	79.7	53	76.5
July 6, 1913	July 10, 1913	4	78.9	Aug. 3, 1913	24	82.5	Aug. 15, 1913	12	85.8	40	83.1
July 8, 1913	July 12, 1913	4	78.2	do	22	83.1	Aug. 16, 1913	13	85.8	39	83.5
Do	do	4	78.2	Aug. 5, 1913	24	82.7	Aug. 17, 1913	12	86.4	40	83.4
July 6, 1913	July 10, 1913	4	78.9	Aug. 4, 1913	25	82.5	do	13	86.1	42	83.3
Do	do	4	78.9	Aug. 5, 1913	26	82.5	Aug. 18, 1913	13	86.1	43	83.3
Do	do	4	78.9	do	26	82.5	do	13	86.1	43	83.2
July 8, 1913	July 12, 1913	4	78.2	Aug. 6, 1913	25	83.2	do	12	86.2	41	83.6
Do	do	4	78.2	Aug. 5, 1913	24	82.7	do	13	86.1	41	83.3
July 6, 1913	July 10, 1913	4	78.9	Aug. 10, 1913	31	83.1	Aug. 21, 1913	11	84.9	46	83.2
Do	do	4	78.9	do	31	83.1	do	11	84.9	46	83.2
Do	do	4	78.9	Aug. 12, 1913	33	83.5	Aug. 23, 1913	11	82.5	48	82.9
July 21, 1916	July 25, 1916	4	79.5	Aug. 11, 1916	17	80.7	Aug. 24, 1916	13	79.3	34	80.0
Do	do	4	79.5	Aug. 13, 1916	19	80.5	Aug. 25, 1916	12	78.6	35	79.7
Do	do	4	79.5	do.[1]	19	80.5	Aug. 26, 1916	13	78.4	36	79.6
July 6, 1913	July 10, 1913	4	78.9	Aug. 14, 1913	35	83.5	do	12	79.8	51	82.3
July 21, 1916	July 25, 1916	4	79.5	Aug. 13, 1916	19	80.5	Aug. 27, 1916	14	78.1	37	79.5
Do	do	4	79.5	Aug. 14, 1916	20	80.3	do	13	78.2	37	79.5
Do	do	4	79.5	do	20	80.3	do	13	78.2	37	79.5
Do	do	4	79.5	do	20	80.3	do	13	78.2	37	79.5
Do	do	4	79.5	do	20	80.3	do	13	78.2	37	79.5
Do	do	4	79.5	do	20	80.3	do	13	78.2	37	79.5
Do	do	4	79.5	do	20	80.3	Aug. 28, 1916	14	77.6	38	79.2
Do	do	4	79.5	Aug. 15, 1916	21	80.3	Aug. 29, 1916	14	76.6	39	78.8
Do	do	4	79.5	Aug. 14, 1916[2]	20	80.3	do	15	76.7	39	78.8
Do	do	4	79.5	do.[3]	20	80.3	Aug. 30, 1916	16	76.1	40	78.5
Do	do	4	79.5	Aug. 15, 1916[4 5]	21	80.3	do	15	76.1	40	78.6
Do	do	4	79.5	do.[6]	21	80.3	do	15	75.9	40	78.5
Do	do	4	79.5	do.[6 7]	21	80.3	Aug. 31, 1916	16	75.4	41	78.3
Do	do	4	79.5	do	21	80.3	Sept. 1, 1916	17	75.6	42	78.3
Do	do	4	79.5	Aug. 19, 1916	25	80.7	Sept. 5, 1916	17	74.0	46	78.1
July 24, 1910	July 28, 1910	4	80.0	Aug. 30, 1910	33	75.3	Sept. 10, 1910	11	79.2	48	76.6
Do	do	4	80.0	Sept. 2, 1910	36	75.6	Sept. 14, 1910	12	78.5	52	76.6
July 31, 1913	Aug. 4, 1913	4	83.1	Sept. 5, 1913	32	80.0	Sept. 19, 1913	14	74.8	50	78.8
Do	do	4	83.1	do	32	80.0	do	14	74.8	50	78.8
Do	do	4	83.1	Sept. 8, 1913	35	80.0	Sept. 28, 1913	20	69.7	59	76.7
Aug. 18, 1917	Aug. 22, 1917	4	73.8	Sept. 21, 1917[1]	30	70.1	Oct. 27, 1917	36	56.9	70	63.5
Do	do	4	73.6	do.[1]	30	70.1	Oct. 28, 1917	37	57.0	71	63.4
Do	do	4	73.6	Sept. 23, 1917	32	69.8	do	35	56.5	71	63.4
Do	do	4	73.6	Sept. 21, 1917	30	70.1	Nov. 6, 1917	46	54.8	80	61.5
Do	do	4	73.6	Sept. 22, 1917	31	70.2	Nov. 6, 1917	45	54.5	80	61.5
Do	do	4	73.6	Sept. 21, 1917	30	70.1	Nov. 8, 1917	48	54.4	82	61.1
Do	do	4	73.6	Sept. 23, 1917	32	69.8	Nov. 10, 1917	48	54.2	84	61.1

[1] 2 individuals.
[2] 12 individuals.
[3] 8 individuals.
[4] 3 individuals.
[5] Forenoon.
[6] 4 individuals.
[7] Afternoon.

PREOVIPOSITION PERIOD

One moth emerged on the night of August 24, 1916, another emerged August 25, and two appeared August 26. Fertile eggs were deposited on the night of September 3, 8 or 10 days after emergence.

EGG STAGE

TABLE 26.—*Duration of egg stage in Lycophotia infecta*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
May 14, 1911	May 18, 1911	4	77.5	Aug. 21, 1913	Aug. 24, 1913	3	72.6
May 21, 1915	May 25, 1915	4	71.2	Sept. 1, 1917	Sept. 6, 1917	5	72.5
May 28, 1914	June 1, 1914	4	80.1	Sept. 3, 1916	Sept. 7, 1916	4	78.6
May 29, 1914	June 2, 1914	4	78.3	Sept. 4, 1916	Sept. 8, 1916 [1]	4	78.7
June 10, 1910	June 14, 1910	4	66.9	Sept. 6, 1916	Sept. 10, 1916	4	76.4
June 12, 1918	June 16, 1918	4	58.1	Do	Sept. 11, 1916	5	76.6
July 6, 1913	July 10, 1913	4	78.8	Sept. 7, 1916	do	4	75.7
July 7, 1913	July 11, 1913	4	79.3	Do	Sept. 12, 1916	5	75.4
July 8, 1913	July 12, 1913	4	78.2	Sept. 8, 1916	Sept. 13, 1916 [1]	5	74.5
July 11, 1913	July 15, 1913	4	79.6	Sept. 9, 1916	Sept. 14, 1916	5	74.0
July 21, 1916	July 25, 1916	4	79.5	Sept. 12, 1916	Sept. 22, 1916	10	61.9
Aug. 18, 1917	Aug. 22, 1917	4	73.8	Sept. 20, 1910	Sept. 25, 1910	5	77.0

[1] 2 lots.

LARVAL STAGE

As shown in Table 25, the larval stage in June, July, and August requires from 17 to 36 days, the majority of the larvae completing their growth in less than four weeks and nearly half of them in about three weeks or less.

PUPAL STAGE

The pupal stage, as shown in Table 25, requires from 11 to 20 days in July, August, and September, nearly all producing moths in about two weeks or less. For September-October and later dates the pupal stage is from 35 to 48 days.

THE VARIEGATED CUTWORM, LYCOPHOTIA SAUCIA HBN.

DISTRIBUTION

This species occurs in America from Alaska to Patagonia; also in Europe and the Mediterranean region generally. Its range includes the entire east-and-west breadth of the United States and Canada and it is here that the species appears to have proven most destructive.

FOOD PLANTS

The observed food plants include alfalfa, *Ambrosia artemisiaefolia*, apple, apricot, asparagus, beet, blackberry, box elder, cabbage, carrot, carnation, cedar, cherry, chickweed, chrysanthemum, clover, cocklebur, corn, cotton, cucumber, currant, dog fennel, Eupatorium, fireweed, gooseberry, grape, grass, hollyhock, honey locust, hop, jimson, knot grass, lemon tree, *Leptilon canadense*, lettuce, soft maple, mulberry, mustard, nettle, onion, orange leaves, osage orange, pansy, pea, sweet pea, peach, pinks, *Plantago lanceolata*, plum, potato, prune, purslane, radish, raspberry, rhubarb, *Rhus copallina*, rose, *Rumex crispus*, rutabaga, sage, smilax, strawberry, sunflower, thistle, timothy, tobacco, tomato, turnip, violet, wheat, and willow.

FOOD HABITS, LARVAL HABITS, AND IMPORTANCE

This species occurs in phenomenal numbers at irregular intervals and has probably caused as much damage as any other cutworm in the United States. Chittenden (*12*) estimated the loss in the United States due to this insect in the great outbreak of 1900 as $2,500,000, and Fletcher (*25*) described the occurrence of this species in Canada the same year as one of the most remarkable outbreaks of an injurious insect that had ever been recorded in that country. The most conspicuous damage in the year mentioned occurred in Washington, Oregon, and northern California, and a correspondent in Seattle reported to Chittenden (*11*) that 200 larvae were taken from about the roots of a single cabbage plant and that a similar number was collected under a shingle overnight. Doane and Brodie (*23*), in connection with this outbreak, state that: "By July 15th the outbreak had become so general, and the number of cutworms was so great, that it seemed as if they would carry everything before them, for they had by this time literally become an invading army, marching on from garden to garden, from field to field, from orchard to orchard, eating every green plant that came in their path." Hundreds of larvae would be found in a raspberry or blackberry bush where they consumed even the tender canes; many young orchards were ruined by having all the buds eaten out of the trees; whole fields of various crops were devastated; and the larvae became a pest in houses.

As evidenced by the list of food plants, the larva is a very general feeder, showing some preference for garden crops and an unusually marked appetite for foliage, buds, and fruit of trees, even including the tannin-impregnated leaves of *Rhus copallina* and the gummy foliage of osage orange, which the larvae obtain by ascending the trunks. Vineyards are also especially subject to injury. Chittenden (*10*) and Slingerland (*58*) consider this to be the most common and destructive cutworm occurring in greenhouses where smilax, the petals of chrysanthemums, and the buds of carnations and roses seem especially subject to attack. Further evidence of a preference for humid situations is provided in the reports of injury to young grapevines, tomato plants, and lettuce in coldframes. The writer has found this to be the most common and destructive species in tobacco-plant beds. The moths evidently make a special effort to oviposit in such beds or upon the canvas covering, since very tightly screened plant beds have repeatedly been found uniformly infested, and beds are not infrequently entirely destroyed. When occurring in large numbers the larvae may assume the armyworm habit and devour the roots of grasses, potato tubers in the soil, and even the bark of trees.

Until they approach maturity the larvae are decidedly less subterranean in habit than most cutworms, sometimes feeding exposed on foliage in the daytime and usually lying stretched out along twigs or other débris on the ground or resting exposed at the base of severed plants. The larger larvae burrow in the soil, although they are also abroad feeding in the daytime when hidden in heavy vegetation.

Seasonal History

There are four broods in this species. Moths begin to appear in small numbers early in February and continue to emerge until the latter part of April. Mature larvae from eggs deposited by these first-brood moths make their appearance about the middle of April and by the latter part of May nearly all of these larvae have completed their growth and are in the soil for pupation. Moths of the second brood begin to emerge the latter part of May and continue to emerge through June. Moths of the third brood begin to appear about the 1st of July and continue until about the middle of August. Moths of the fourth brood begin to emerge the latter part of July and continue to emerge until November at least, and these produce the overwintering stages.

Moths have emerged outdoors under normal conditions as early as March 19, 1913, and the only moth taken in the field earlier than this was a male taken February 2, 1916. The occurrence of hibernation in the adult stage seems doubtful. Mature larvae have been taken in the field February 12, 1916, and March 20, 1913, and a fourth-instar larva was collected January 18, 1919, at Hixson, Tenn., by J. U. Gilmore. These larvae undoubtedly had hibernated, but hibernation in this stage is certainly rare in this latitude. Pupae have been repeatedly carried through the winter and this is evidently the normal overwintering stage for this species.

Forbes (*28*) states that the larvae are most destructive in Illinois in May and early June, and that moths appear in abundance the latter part of June. Gillette (*34*) found moths in Iowa throughout the growing season, but they were most abundant in October. Garman (*32*) has found that larvae enter the soil for pupation during the early part of June and moths begin to emerge the latter part of June and continue common until fall, the latest date of capture being October 25. Doane and Brodie (*23*) record, in connection with the great outbreak in Washington State, that the larvae were exceedingly destructive on July 25, but had begun to disappear rapidly by about the 1st of August, and few were usually to be found by the 12th or 15th of August. They took moths from April 6 to November 6, most of them in June and July and again in September and October. Gibson (*33*) considers that there are two broods in Canada, "the moths appearing in June and again about the middle of August."

Description of Stages

Adult

The moth (pl. 3, D) does not possess any marked characters by which it may be positively characterized, and yet it is not a difficult one to distinguish. The forewings are yellowish or brownish, more or less obscured by black, and the transverse lines are often represented only by distinct black dashes on the costa. The hind wings are white, with the veins more or less shaded dark. Expanse about 1½ or 2 inches.

EGG

The egg (pl. 5, A) is white, circular in outline, with the base narrowed and flat and the apex slightly convex, 0.55 to 0.58 mm. broad and 0.40 to 0.45 mm. high, with about 35 to 40 longitudinal ribs and many slender transverse lines. In from 2 to 4 days after deposition the egg develops a girdle and micropylar splotch of reddish brown or sometimes becomes entirely brown.

The eggs are deposited, without covering, in a single layer including several hundred eggs on foliage, twigs, fences, buildings, and even on washings hanging on the line, and the moths seem to have a special preference for tobacco-plant beds as places of oviposition. A moth taken in the field April 11, 1913, deposited 1,356 eggs during the following 12 days. Another frayed moth taken in a bait trap March 24, 1917, deposited 1,430 eggs during the following 15 days. The moth evidently oviposits over a considerable period.

LARVA

In this species there is a distinct yellow or pale dot middorsally on the disc of each abdominal segment, at least anteriorly, and a large dorsal pale area following the eighth abdominal segment. In well-marked specimens there is a fuscous W-shaped mark on the eighth abdominal segment just preceding the pale area, a series of linear subdorsal markings, and an inconspicuous, sinuous, dark band above the spiracles. Adfrontal setae 2 are also set distinctly less than twice their width apart from the apex of the occipital foramen.

First instar.—Head 0.32 mm. broad. Body about 2 to 3 mm. long and 0.35 mm. broad; of about equal width throughout; skin rather closely granulose ventrally, scarcely at all dorsally; ferruginous both dorsally and ventrally (without markings early in the instar) with more or less infuscation dorsally particularly in a band above the spiracles, a middorsal line, two supraspiracular lines, and a broad, conspicuous band below the spiracles, pale. Cervical shield dark fuscous, trapezoidal. Anal shield dark fuscous, U-shaped, open posteriorly. Head shield black. Setigerous tubercles very dark fuscous, those on the thorax longitudinal, others of an irregular rounded outline, I and IV of abdomen of about equal size, II, III, and V smaller and of about equal size, their setae dark fuscous, long and capitate. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10, those on third segment much reduced in size but bearing two crochets.

Second instar.—Head 0.46 to 0.50 mm. broad. Body about 3.6 to 6.5 mm. long and 0.6 mm. broad; of about equal width throughout; dilute brownish to dark ferruginous, a pale broken middorsal and pair of supraspiracular lines and a broad white band below the spiracles, pale below. Setigerous tubercles large, fuscous, not conspicuous, I of abdomen twice as large as II on first six abdominal segments and larger than any of the other tubercles, their setae dark fuscous, long and capitate. Head shield, cervical shield, and anal shield pale grayish, the bases of the setae fuscous, very distinct, the head shield indefinitely reticulated with obscure brownish. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10. Larva travels with a decided looper gait.

Third instar.—Head 0.80 mm. broad. Body about 5.3 to 9 mm. long and 1 mm. broad; slightly enlarged on the first three and the eighth abdominal segments; skin smooth; dorsally a mixture of dark fuscous or infuscated brownish and gray becoming more brownish posteriorly, a middorsal yellowish line broken on the thorax and first three abdominal segments and more distinct on posterior margins of all, a velvety black splotch on dorsum of first, second, third, and eighth abdominal segments, the eighth posteriorly and ninth usually distinctly paler than the remainder of the dorsal area, supraspiracular area occupied by a dark band, darker below and with two whitish lines in upper half, a subspiracular yellow band with a continuous pink center, beneath a mixture of livid, whitish and pinkish. Cervical shield distinctly narrowed posteriorly, with three yellowish lines. Anal shield nearly concolorous with adjacent parts. Head shield pale brownish gray, a dark band beside the front and another including the ocelli. Setigerous tubercles black, I larger than II, III as large as I. Spiracles protuberant, large, shining. Legs and shields of prolegs dark fuscous. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10. Larva has a looper gait.

Fourth instar.—Head 1.2 mm. broad. Body about 12 to 16 mm. long; very slightly enlarged on eighth abdominal segment, general color pale clear gray overlaid heavily with black, a faint, pale middorsal line demarked with black and forming a distinct dot on the posterior margin of the abdominal segments at least on first three segments, a distinct irregular dark splotch on dorsum of eighth abdominal segment followed by a large pale area, supraspiracular area dark, sometimes with traces of two pale lines above, sooty black on lower half, the upper, subdorsal, margin with a series of linear dark spots, below the spiracles a yellowish band with pinkish center, below an equal mixture of fuscous and whitish. Setigerous tubercles not conspicuous, black, I and II of abdomen of about equal size, margined with white. Cervical and anal shields concolorous with adjacent parts. Head shield white, submedian arcs heavy, dark fuscous, confluent above the apex of the front where they inclose a reticulate area of the size of the front, laterally reticulated with dark fuscous tending to brown medially. Spiracles black. Legs brownish. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10. The larvae no longer travel with a looper gait.

Fifth instar.—Head 1.9 to 2 mm. broad. Body about 25 to 28 mm. long and 4 mm. broad; of about equal width throughout but slightly enlarged on eighth abdominal segment; general color above the spiracles a mixture of pink sh ferruginous and pale yellowish overlaid with flecks and spots of black, dorsal area with an obscure yellowish median line forming a distinct yellow dot on the first four abdominal segments and demarked throughout at least on the posterior portion of the segments with black, eighth abdominal segment with a W-shaped black mark open anteriorly followed by a distinct paler area, subdorsally a segmental series of linear black spots absent in very pale specimens, connected by a broken yellow or orange line, forming a dot about midway of each segment, supraspiracular area occupied by a sinuous black band narrowed at the spiracles, below the spiracles a pink:sh or orange band margined above with yellow, below paler closely flecked with whitish. Cervical shield small, indistinct. Anal shield concolorous with adjacent parts. Head shield ground color pale yellowish, submedian arcs broad, inclosing a reticulate area above the apex of the front and flanked laterally by an area reticulate, if at all, with ferruginous, outside this area on posterior margin of head shield an area of fuscous reticulation, the reticulation fused anteriorly to form a dist:nct line. Setigerous tubercles minute, black. Spiracles black. Legs brownish. Prolegs pale, their shields fuscous.

Sixth instar (pl. 7, H, N).—Head 3 to 3.2 mm. broad. Body about 35 to 46 mm. long and 6 mm. broad; of about equal width throughout, the posterior extremity somewhat enlarged and very blunt; skin smooth; general color varying from very pale gray to rather dark fuscous, the latter being more nearly normal, the ground color a dirty yellowish gray, pale middorsal line visible on cervical shield and sometimes on the thorax, represented on the first four abdominal segments by a distinct yellow dot which may also occur on some of the following segments where it is demarked with black, a fuscous W-shaped mark open anteriorly on dorsum of eighth abdominal segment followed by a conspicuous yellowish or orange area, subdorsally a segmental series of linear black spots bordered below by a broken yellowish or orange line which forms an inconspicuous dot near the middle of each segment, supraspiracular area occupied by an inconspicuous, sinuous dark band narrowed or more or less obsolete at the spiracles, below the spiracles a margin of mingled yellow and orange, below pale flecked with white. Cervical shield narrowed posteriorly, with a narrow median and two broader lateral lines, nearly concolorous with adjacent parts. Head shield ground color pale whitish with broad black submedian arcs inclosing a reticulate area above the apex of the front, more or less fuscous reticulate laterally, the reticulation fused to form a distinct subdorsal line, area between this line and the submedian arcs subobsoletely ferruginous reticulate, adfrontal sutures pale, terminating somewhat before reaching the occipital foramen. Setigerous tubercles minute, inconspicuous, of practically equal size, outwardly more or less margined with white. Spiracles black. Anterior pair of prolegs each with about 18 to 23 crochets.

Mouth parts: Mandibles of the ordinary type. Hypopharynx much as in *Agrotis ypsilon*, lingua occupying about one-third the length, blade of maxillulae with about 12 to 15 long, strongly tapering, flat, nearly or quite contiguous teeth with long, aciculate tips. Spinneret rather broad and short, with the apex produced into bizarre setiform processes. Labial palpi with the segments in the proportion of 22, 3.5, and 9.

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. A^2 approximately twice as near to A^1 as to P^a. A^a distinctly nearer to A^2 than to A^3. A^a approximately twice as near to A^2 as to P^a. P^b, A^1, and A^2 not in a straight line. O^2 either approximately equidistant from L^1 and A^3 or nearer to A^3. O^2 nearly or quite equidistant from O^1 and A^3 or nearer to A^3. SO^a nearly or quite directly anterior to SO^3 and distinctly twice or more nearer to SO^3 than to SO^2. SO^3 approximately equidistant from G^1 and O^3 or somewhat nearer to O^3. G^1 slightly nearer to O^3 than to SO^3. G^1 distinctly nearer to G^a than to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa.*

PUPA

Pupa (fig. 18, A, B) about 15 to 23 mm. long and 5 to 6 mm. broad, maxillary palpi not visible, labrum not emarginate, prespiracular callus absent on prothorax, abdominal punctures small, round, spiracles broad, directed laterally, cremaster without spinules, spines rather short, yellow on apical half, parallel basally, divergent apically, without a distinct basal process, areas both anterior to and below the spines smooth.

LIFE HISTORY

TABLE 27.—*Length of generations in Lycophotia saucia*

Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
		Days	°F.		Days	°F.		Days	°F.	Days	°F.
Apr. 4, 1917	Apr. 18, 1917	14	54.5	May 26, 1917	38	60.7	June 12, 1917	17	68.7	69	61.4
Apr. 1, 1917	Apr. 17, 1917	16	52.2	do	39	60.9	do	17	68.7	72	60.8
Apr. 6, 1917	Apr. 18, 1917	12	55.8	May 25, 1917	37	60.4	do	18	68.9	67	61.9
Mar. 24, 1917	Apr. 8, 1917	15	53.1	May 26, 1917	48	59.9	June 13, 1917	18	68.6	81	60.6
Apr. 8, 1917	Apr. 18, 1917	10	56.8	May 27, 1917	39	61.1	do	17	68.1	66	62.3
Do	do	10	56.8	May 26, 1917 [1]	38	60.7	do	18	68.6	66	62.3
Do	do	10	56.8	May 25, 1917	37	60.4	do	18	68.7	66	62.2
Do	do	10	56.8	May 28, 1917	40	61.0	do	16	68.4	66	62.2
Mar. 24, 1917	Apr. 8, 1917	15	53.1	May 26, 1917	48	59.9	June 14, 1917	18	68.5	82	60.6
Apr. 8, 1917	Apr. 18, 1917	10	56.8	May 27, 1917 [1]	39	61.1	do	18	68.0	67	62.3
Mar. 24, 1917	Apr. 8, 1917	15	53.1	do.[1]	49	60.2	do	18	68.0	82	60.6
Mar. 26, 1917	Apr. 10, 1917	15	57.5	May 26, 1917	46	60.5	June 15, 1917	20	67.9	81	61.8
Apr. 4, 1917	Apr. 18, 1917	14	54.5	May 29, 1917	41	61.0	do	17	68.1	72	61.4
Apr. 8, 1917	Apr. 24, 1917	16	60.0	May 27, 1917	33	60.3	do	19	67.5	68	62.2
Do	do	16	60.0	do	33	60.3	June 16, 1917	20	66.9	69	62.1
Apr. 11, 1913	Apr. 22, 1913	11	----	----	----	----	June 16, 1913 [1]	----	----	66	69.9
Do	do	11	----	----	----	----	June 17, 1913 [2]	----	----	67	70.1
Do	do	11	----	----	----	----	June 18, 1913 [3]	----	----	68	70.4
Apr. 4, 1917	Apr. 18, 1917	14	51.1	May 29, 1917	41	61.0	June 18, 1917 [1]	20	67.3	75	----
Mar. 24, 1917	Apr. 8, 1917	15	53.1	May 28, 1917	50	60.2	do	21	67.0	86	----
Apr. 11, 1913	Apr. 22, 1913	11	----	----	----	----	June 19, 1913 [4]	----	----	69	70.6
Do	do	11	----	----	----	----	June 20, 1913 [5]	----	----	70	70.9
Do	do	11	----	----	----	----	June 21, 1913 [6]	----	----	71	71.1
Do	do	11	----	----	----	----	June 22, 1913 [7]	----	----	72	71.3
Do	do	11	----	----	----	----	June 23, 1913 [7]	----	----	73	71.6
Do	do	11	----	----	----	----	June 24, 1913	----	----	74	71.8
June 15, 1916	June 20, 1916	5	69.2	July 5, 1916	15	76.0	July 19, 1916	14	77.4	34	75.6
Do	do	5	69.2	July 13, 1916 [8]	23	75.7	July 25, 1916	12	80.0	40	76.1
Do	do	5	69.2	do	23	75.7	do	12	80.0	40	76.1
Do	do	5	69.2	do	23	75.7	July 27, 1916	14	80.3	42	76.4
Do	do	5	69.2	do	23	75.7	do	14	80.3	42	76.4
Do	do	5	69.2	do	23	75.7	July 28, 1916	15	80.2	43	76.5
June 18, 1916	June 23, 1916	5	74.8	July 15, 1916	22	75.9	do	13	80.4	40	77.2
Do	do	5	74.8	July 16, 1916	23	76.2	July 29, 1916	13	80.4	41	77.3
June 15, 1916	June 20, 1916	5	69.2	July 15, 1916	25	76.0	do	14	80.5	44	76.7
Do	do	5	69.2	July 16, 1916	26	76.2	do.[1]	13	80.4	44	76.7
Do	do	5	69.2	July 17, 1916	27	76.4	do.[1]	12	80.4	44	76.7
Do	do	5	69.2	do	27	76.4	July 30, 1916	13	80.4	45	76.8
Do	do	5	69.2	July 18, 1916	28	76.6	July 31, 1916	13	80.5	46	76.9
Do	do	5	69.2	do	28	76.6	do	13	80.5	46	76.9
June 21, 1916	June 26, 1916	5	73.0	July 21, 1916	25	77.7	Aug. 2, 1916	12	80.5	42	77.9
Do	do	5	73.0	do	25	77.7	Aug. 3, 1916	13	80.5	43	78.0
Do	do	5	73.0	do	25	77.7	Aug. 4, 1916	14	80.6	44	78.0
Do	do	5	73.0	July 25, 1916	29	77.9	Aug. 6, 1916	12	81.0	46	78.2
Do	do	5	73.0	do	29	77.9	do.[1]	12	81.0	46	78.2
June 26, 1913	July 1, 1913	5	86.6	July 23, 1913	22	77.7	Aug. 7, 1913	15	84.2	42	81.1
June 27, 1913	do	4	86.6	July 28, 1913	27	78.2	Aug. 10, 1913	13	85.3	44	81.1
June 26, 1913	do	5	86.6	do	27	78.2	Aug. 11, 1913 [9]	14	85.3	46	81.3

[1] 2 individuals.
[2] 5 individuals.
[3] 18 individuals.
[4] 16 individuals.
[5] 9 individuals.
[6] 6 individuals.
[7] 5 individuals.
[8] Afternoon.
[9] 3 individuals.

TABLE 27.—*Length of generations in Lycophotia saucia*—Continued

Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
		Days	° *F.*		*Days*	° *F.*		*Days*	° *F.*	*Days*	° *F.*
June 26, 1913	July 1, 1913	5	86.6	July 29, 1913	28	78.4	Aug. 11, 1913	13	85.0	46	81.2
June 27, 1913	do	4	86.6	July 28, 1913	27	78.2	do	14	85.3	45	81.1
Do	do	4	86.6	do	27	78.2	do	14	84.7	45	81.0
June 26, 1913	do	5	86.6	July 30, 1913	29	78.5	Aug. 13, 1913	14	84.3	48	81.0
June 27, 1913	do	4	86.6	do	29	78.5	do	14	84.3	47	80.9
Aug. 3, 1916	Aug. 7, 1916	4	82.2	Sept. 7, 1916	31	76.7	Sept. 25, 1916	18	65.6	53	73.3
Aug. 2, 1916	Aug. 6, 1916	4	81.7	Sept. 4, 1916	29	76.7	Sept. 27, 1916	23	68.2	56	73.6
Aug. 5, 1916	Aug. 9, 1916	4	78.9	Sept. 8, 1916	30	79.6	Oct. 4, 1916	26	63.6	60	72.6
Do	do	4	78.9	Sept. 13, 1916	35	78.9	Oct. 10, 1916	27	62.7	66	72.3
Do	do	4	78.9	Sept. 14, 1916	36	78.6	Oct. 12, 1916	28	61.9	68	71.7
Do	do	4	78.9	Sept. 21, 1916	43	75.5	Oct. 13, 1916	22	63.0	69	71.7
Aug. 12, 1916	Aug. 16, 1916	4	79.2	do	36	74.6	Oct. 16, 1916	25	60.8	65	69.6
Aug. 5, 1916	Aug. 9, 1916	4	78.9	Sept. 25, 1916	47	74.3	Oct. 19, 1916	24	63.0	75	70.9
Aug. 11, 1916	Aug. 15, 1916	4	78.6	Sept. 22, 1916	38	74.4	do	27	62.9	69	70.2
Aug. 10, 1916	Aug. 14, 1916	4	79.7	do	39	74.6	Oct. 21, 1916	29	61.4	72	69.6
Aug. 5, 1916	Aug. 9, 1916	4	78.9	Sept. 26, 1916	48	74.3	Oct. 24, 1916	28	60.3	80	69.6
Do	do	4	78.9	Sept. 25, 1916	47	74.3	Oct. 25, 1916	30	62.4	81	70.1
Aug. 11, 1916	Aug. 15, 1916	4	78.6	Sept. 27, 1916	43	73.5	Oct. 29, 1916	32	61.0	79	68.7

PREOVIPOSITION PERIOD

One moth emerged on the night of July 19, 1916. Two others emerged on the night of July 25 and two July 27. The first fertile eggs were deposited on the night of August 2, 6 or 8 days after the appearance of the first pair and 14 days after the emergence of the first moth.

EGG STAGE

TABLE 28.—*Duration of egg stage in Lycophotia saucia*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Mar. 26, 1917	Apr. 10, 1917	15	54.4	June 21, 1916	June 26, 1916	5	73.0
Mar. 27, 1917	Apr. 11, 1917	15	54.6	June 26, 1913	July 1, 1913	5	86.6
Apr. 1, 1917	Apr. 17, 1917	16	51.7	June 27, 1913	do	4	86.6
Apr. 4, 1917	Apr. 18, 1917	14	52.7	June 29, 1917	July 4, 1917	5	73.6
Apr. 6, 1917	do	12	54.9	Aug. 2, 1916	Aug. 6, 1916	4	81.7
Apr. 8, 1917	do	10	55.7	Aug. 3, 1916	Aug. 7, 1916 [1]	4	82.2
Apr. 11, 1913	Apr. 22, 1913	11	57.2	Aug. 4, 1916	Aug. 8, 1916	4	80.8
Apr. 14, 1913	Apr. 23, 1913	9	61.6	Aug. 5, 1916	Aug. 9, 1916	4	78.9
Apr. 16, 1913	Apr. 24, 1913	8	65.4	Aug. 10, 1916	Aug. 14, 1916	4	79.7
Apr. 17, 1913	do	7	66.3	Aug. 11, 1916	Aug. 15, 1916	4	78.6
Apr. 20, 1914	Apr. 26, 1914	6	69.8	Aug. 12, 1916	Aug. 16, 1916	4	79.2
Apr. 22, 1913	May 2, 1913	10	62.8	Aug. 14, 1916	Aug. 18, 1916	4	82.0
May 26, 1914	May 30, 1914	4	81.0	Aug. 27, 1917	Sept. 2, 1917	6	72.0
June 15, 1916	June 20, 1916 [1]	5	69.2	Sept. 12, 1917	Sept. 18, 1917	6	69.3
June 16, 1912	June 22, 1912 [1]	6	72.1	Oct. 24, 1915	Nov. 3, 1915	10	58.7
June 19, 1911	June 23, 1911	4	73.5	Oct. 30, 1915	Nov. 8, 1915	9	60.5
June 18, 1916	do	5	74.8	Oct. 31, 1915	Nov. 9, 1915 [1]	9	58.2

[1] 2 sets of eggs.

LARVAL STAGE

As shown in Table 27, the larval stage in April-May and the latter part of August-September requires from 33 to 50 days, with about half the larvae completing their growth in about 40 days or less. The June-July larvae require from 15 to 29 days for development, only one completing this stage in less than 3 weeks and only four requiring as much as 29 days.

PUPAL STAGE

In addition to the pupal stages given in Table 27, those given in Table 29 have been recorded.

TABLE 29.—*Duration of pupal stage in Lycophotia saucia*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	°*F.*			*Days*	°*F.*
Mar. 27, 1913	May 3, 1913	37	59.6	May 21, 1913	June 8, 1913	18	73.2
Apr. 19, 1916	May 12, 1916	23	61.9	May 20, 1913	do	19	73.1
Do	May 13, 1916	24	62.2	May 23, 1911	June 8, 1911	16	67.2
May 16, 1913	June 3, 1913 [1]	18	72.0	May 24, 1911	June 9, 1911	16	67.2
May 18, 1913	June 4, 1913	17	72.4	July 20, 1915	Aug. 3, 1915	14	79.7
May 17, 1913	do	18	72.3	July 22, 1913	Aug. 5, 1913	14	83.5
May 18, 1913	June 5, 1913 [1]	18	72.7	Oct. 5, 1914	Nov. 7, 1914	33	60.8
May 17, 1913	do	19	72.6	Do	Nov. 8, 1914 [1]	34	60.7
May 16, 1913	do.[2]	20	72.6	Oct. 6, 1914	Nov. 10, 1914	35	59.5
May 19, 1913	do	17	72.9	Oct. 4, 1914	Nov. 11, 1914	38	59.9
May 18, 1913	June 6, 1913	19	73.1	Oct. 6, 1914	do	36	59.3
May 19, 1913	do	18	73.2	Oct. 7, 1914	Nov. 12, 1914	36	57.2
Do	June 7, 1913	19	73.4	Oct. 8, 1914	do	35	56.7
May 20, 1913	do	18	73.5	Do	Nov. 14, 1914	37	57.2
May 19, 1913	June 8, 1913	20	73.1	Do	Nov. 15, 1914	38	57.3

[1] 2 individuals. [2] 3 individuals.

In 1914, 57 larvae pupated on dates between October 4 and October 25. The number which hibernated and the number which emerged the same season for each date are shown in Table 30.

TABLE 30.—*Critical date of pupation for hibernation in L. saucia*

Date pupated	Number pupated	Number emerged	Number hibernated	Date pupated	Number pupated	Number emerged	Number hibernated
Oct. 4, 1914	1	1	0	Oct. 16, 1914	1	0	1
Oct. 5, 1914	3	3	0	Oct. 17, 1914	2	0	2
Oct. 6, 1914	3	2	1	Oct. 18, 1914	8	0	8
Oct. 7, 1914	1	1	0	Oct. 19, 1914	4	0	4
Oct. 8, 1914	12	4	8	Oct. 20, 1914	1	0	1
Oct. 9, 1914	4	0	4	Oct. 21, 1914	4	0	4
Oct. 10, 1914	3	1	2	Oct. 22, 1914	4	0	4
Oct. 11, 1914	2	2	0	Oct. 23, 1914	1	0	1
Oct. 15, 1914	2	0	2	Oct. 25, 1914	1	0	1

October 11 was the last date for pupation which resulted in the emergence of moths in November, and one of the pupae formed October 6 hibernated. The latter date is apparently near the dividing line for pupation with regard to whether the moths emerge in November or in the following spring.

PARASITES AND PREDATORS

Of 800 larvae of this species collected in May, 1920, about 2 or 3 per cent bore the firm-shelled whitish eggs of a species of fly, determined by Aldrich as *Winthemia quadripustulata* Fab., which emerged in June. *Microplitis varicolor* Vier. was obtained in May, 1912. The cocoon was spun beside the still living larva which was in the second or third instar. *Sagaritis provancheri* (D. T.) was also obtained from larvae, the skin of the host being attached to the cocoon. Freshly killed larvae have been found on several occasions accompanied by adults of Scarites, and on one occasion a fifth-instar larva had been killed by a nymph of *Podisus maculiventris* Say, which was carrying the larva on its beak. The writer also found a bombyliid pupa in a pupal shell on June 24, 1911, but failed to obtain the fly.

In 1921, 110 larvae were collected when nearly mature and reared in tin boxes with unsterilized field earth. Mortality was as follows:

Moths emerged		50
Parasitized		19
Insects:		
Sagaritis dubitatus Cress	1 larva.	
Meteorus autographae Mues	7 larvae.	
Winthemia 4-pustulata Fab	2 larvae.	
Nematode:		
Mermis sp	1 larva.	
Disease:		
Bacterial disease (?)	7 larvae.	
Polyhedral disease (?)	1 larva.	
Died as larvae without apparent cause		40
Died as pupa without apparent cause		1

The Meteorus occurs singly in the host larva and upon emerging suspends its cocoon by a thread about half an inch long.

French (*30*) found a mite (*Uropoda americana* Riley) on a larva, but this may not have been predacious. Coquillett (*19*) records *Chaetogaedia monticola* Bigot, *Gonia capitata* DeG., and *Winthemia quadripustulata* Fab. from this species. Doane and Brodie (*23*) bred (*Ichneumon*) *Amblyteles maurus* (Cress.) from larvae and *Meteorus indagator* Riley from pupae, and noted that many larvae were killed early in August by a bacterial disease. Dipterous parasites were present in large numbers. Chittenden (*11*) found *Madremyia saundersii* Will., the larva of a therevid, *Archytas analis* Fab., and (*Icheneumon*) *Amblyteles cupitus* (Cress.) parasitic. The last named had parasitized fully 50 per cent of one lot of pupae. He found *Scarites subterreneus* Fab. predacious on larvae. Wakeland (*78*) reared *Gonia sequax* Will., *Archytas analis* Fab., (*Linnaemyia*) *Bonnettia compta* (Fall.), and *Chaetogaedia monticola* Bigot among dipterous parasites, and among the Hymenoptera he obtained (*Pimpla*) *Ephialtes sanguineipes* (Cress.), *Meteorus* (*millinervis* Vier.) *vulgaris* Cress., and the hyperparasite *Dibrachys boucheanus* Ratz. Burgess and Collins (*8*) record *Calosoma peregrinator* Guer. and *Calosoma semilaeve* Lec. as feeding on larvae of *saucia*. *Enicospilus purgatus* Say has also been reported from this species. Muesebeck (*50*) records *Meteorus vulgaris* Cress. and *M. laphygmae* Vier. as parasites. Aldrich and Webber (*2*) include this species among the hosts of *Madremyia saundersii* Will.

GENUS POLIA

GENERAL CHARACTER OF LARVAE

Of the species of this genus included here, *renigera* and *meditata* are certainly closely related, but *legitima* gives very little indication of special affinity with these species, the character of the spinneret being about the only common distinctive feature. All of the species have protective coloration developed to an unusual degree. None of the species gives any indication of special relationship with any of the other genera here treated.

STRIPED GARDEN CATERPILLAR, POLIA LEGITIMA GRT.

Distribution

Polia legitima occurs throughout the eastern part of the United States; west of the Mississippi River it is reported from Kansas, Oklahoma, and Oregon, indicating that the entire breadth of the country may be included in its range. The species is also reported from Canada. Larvae have been examined from Lincolnville, Me., Holderness, N. H., Virginia, Clarksville, Tenn., and Galena, Kans.

Food Plants and Habits

The recorded food plants include asparagus, seeds of *Asclepias incarnata*, *Agrostis hyemalis*, blackberry, cabbage, clover, collards, *Muhlenbergia gracillima*, pea, rape, rutabaga, *Salix humilis*, Solidago, *Syntherisma sanguinale*, tobacco, turnip, and violet. Howard (*37*) first recorded this species from tobacco, and the writer occasionally has found it feeding on tobacco at Clarksville, but the injury done by this species is negligible and the cutting habit is apparently absent.

The larvae appear to be general feeders, but their normal food is probably the slender grasses upon which this boldly striped larva becomes remarkably inconspicuous as it lies extended along the stems. Larvae have been collected from Muhlenbergia and Agrostis on numerous occasions, but very rarely have they become visible until dislodged from the plants. They are not at all subterranean in habits but feed and rest exposed on their food plants, and the highly protective coloration is undoubtedly of much value to the species.

Chittenden (*13*) states that the larva is somewhat partial to asparagus, cruciferous plants, peas and other legumes, but that it feeds upon a number of vegetables and other plants, including violets in greenhouses. He observed the remarkable effect of the coloration of the larva upon its visibility.

Seasonal History

This is a single-brooded species. The winter is passed in the pupal stage. The pupae, after lying in the soil for nine months or more, begin to produce moths about the first of August and moths continue to emerge through August and are found on the wing until about the middle of September. Larvae from these begin to attain mature size about the first of October, and pupation begins the fore part of October, although some active larvae are found up to the latter part of November.

The pupal stage in this species is unusually long, and an adaptation to this condition is seen in the fact that the pupae are highly resistant to desiccation since they may be left exposed on the surface of dry soil for months and will still be in apparently normal condition. Another remarkable feature of the pupal stage is indicated by a single record showing that a bred pupa broken open March

27, 1915, contained a nearly fully developed live moth, although moths do not begin to emerge until the first of August.

Chittenden (*13*) records larvae from October 3 to the last week in November and moths from July 25 to September 16. Larvae which entered the soil during the third week in October pupated shortly afterward and the moths began to emerge on August 21 of the following year. It will be noted that these records are closely parallel to the seasonal history worked out independently at Clarksville.

Description of Stages

ADULT (PL. 3, A)

Forewings pale gray, with the base, an area about the reniform spot and extending broadly along the costa outwardly, and a subapical transverse band chiefly reddish brown, the margins of the orbicular laterally, and of the reniform posteriorly, a series of marks along the costa, a series of dots on the veins in the pale transverse subapical area, a transverse dash below the reniform spot, and the claviform spot nearly or quite black. The claviform spot is a small but prominent angular mark as shown in the illustration. The hind wings are fuscous, more dilute basally. The wings beneath are tinged marginally with reddish. Expanse 1½ inches or slightly less.

EGG

The egg is white, circular in outline, the sides parallel, the upper surface including the micropylar area uniformly convex, 0.60 mm. broad and 0.46 mm. high, with about 35 moderately strong slightly sinuate ribs and many faintly indicated transverse lines, the base smooth. On about the second day after deposition the egg becomes almost entirely suffused with dark pink. A mass of about 150 eggs of this species was taken on a blade of grass in the field August 31, 1917. They were without any trace of scaly covering.

LARVA

In this larva the body tapers decidedly posteriorly and bears prominent black and yellow stripes (pl. 5, C, J) and the mandibles have a complicated internal structure (fig. 6, B). The features presented in the illustrations will serve to distinguish this species from any other larva known to the writer.

First instar.—Head 0.36 mm. broad. Body about 2.8 to 3.7 mm. long and 0.5 mm. broad at middle; skin set very closely both dorsally and ventrally with minute conical granules; tapering from the prothorax posteriorly with the first three abdominal segments of about equal width; color uniform gray (or green from the food) without markings. Cervical shield infuscated brown, trapezoidal. Anal shield fuscous, transversely rhomboidal. Head shield light brown obscurely flecked with darker brown, without arcs or reticulation. Setigerous tubercles fuscous, of about uniform size, their setae long, fuscous, scarcely capitate. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10.

Second instar.—Head 0.69 mm. broad. Body about 5.5 mm. long and 0.72 mm. broad at middle; of nearly uniform width throughout but narrowing slightly posteriorly; skin smooth; with middorsal, subdorsal, and supraspiracular pale lines alternating with prominent pale fuscous stripes, black immediately above the spiracles, a white subspiracular band, venter pale. Cervical and anal shields concolorous with adjacent parts. Head shield very pale brown without markings. Setigerous tubercles fuscous, not very conspicuous, I on abdomen larger than II except on abdominal segments 7 and 8, III of same size as I, IV equaling II, III, IV, and V distant from the spiracle in the order named, III and IV nearly equidistant. Spiracles pale brown, round, the one on seventh abdominal segment much the largest. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10.

Third instar.—Head 0.95 mm. broad. Body about 10 mm. long and 1 mm. broad at middle; of about equal width throughout but tapering slightly posteriorly; skin smooth; with longitudinal stripes and lines as follows: Middorsal line and line dividing the fuscous supraspiracular band white, subdorsal and subspiracular bands yellow, the above alternating with fuscous, the lower half of the supraspiracular band the darker, venter pale. Head shield ground color pale, with the median and ocellar arcs brown. Cervical and anal shields not distinguishable. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10, the first four pairs becoming gradually longer posteriorly. Tubercles and their setae minute. Legs pale brownish.

Fourth instar.—Head 1.4 mm. broad. Body about 12 mm. long and 1.5 mm. broad at middle; tapering distinctly posteriorly; coloration as in the third instar except that the lower half of the supraspiracular band is now black, middorsal pale line still continuous. Spiracles pale yellowish with dark rims.

Fifth instar.—Head 2.1 mm. broad. Body about 23 mm. long and 2.5 mm. broad at middle; tapering distinctly posteriorly; skin smooth; coloration much as in the mature larva, dorsal area black, the middorsal pale line prominent on the prothorax, obsolescent posteriorly, subdorsal and subspiracular yellow stripes conspicuous, supraspiracular band divided medially by a pale line, the upper half of the band pale lavender, the lower half, including the spiracles, jet back, a lavender or pinkish shade below the yellow subspiracular band. Head shield ground color pale, with traces of reticulation in the brown median and ocellar arcs which are fused on the posterior margin of the head shield.

Sixth instar (pl. 8, C, J).—Head 3 to 3.2 mm. broad. Body about 35 mm. long and 5 mm. broad at middle; broadest through abdominal segments 3, 4, and 5, tapering decidedly posteriorly; skin smooth; dorsal area black, the middorsal line obsolete except on the prothorax, prominent subdorsal and subspiracular yellow bands, supraspiracular band divided by a pale line, the upper part salty gray, the lower, including the spiracles, jet black, a lavender or pinkish shade below the subspiracular yellow band. Ground color of head shield pale yellowish, the clear brown submedian and ocellar arcs fused so as to cover most of the head shield; adfrontal sutures terminating distinctly before reaching the occipital foramen. Tubercles and their setae minute. Prolegs of about equal length, each of the anterior pair with about 18 to 23 crochets.

Mouth parts: Mandibles with a complicated internal structure (fig. 6, B). Hypopharynx suboval, long and narrow, broadest posteriorly, lingua occupying somewhat less than half the length of the part, set throughout, except in the premaxillulary area, with minute spines or spinules, slightly heavier anteriorly, arranged in transverse lines posteriorly, premaxillulary area set closely with short, stout spines, maxillulae clothed throughout with slender, appressed spinules, blade of maxillulae with about 20 distinctly isolated, terete, acutely pointed teeth, gorge bare except anteriorly. Spinneret nearly three times as long as broad, distinctly exceeding the basal segment of the labial palpus, tapering slightly to the truncated tip. Labial palpi with the segments in the proportion of 26, 5, and 12.

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. A^2 approximately equidistant from A^1 and A^a or somewhat nearer to A^a. P^1 distinctly nearer to Adf^2 than to Adf^1. P^1 on or above the level of Adf^2. P^a decidedly above the level of Adf^1. P^b, A^2 and A^1 not in a straight line. Interspaces A^2 to A^a and P^1 to P^a approximately equal. O^1 posterior to the line connecting the centers of ocelli IV and VI, but very near the line—within the curve of the ocelli. Punctures F^a below the level of setae F^1. O^2 slightly less than twice as near to A^3 as to L^1. O^2 slightly nearer to A^3 than to O^1. O^2 approximately equidistant from O^1 and O^3. L^1 about three times as near to L^a as to O^2. SO^a slightly nearer to SO^3 than to SO^2. SO^3 somewhat nearer to O^3 than to G^1. G^1 distinctly nearer to O^3 than to SO^3. G^a somewhat nearer to G^1 than to O^3. G^1 two or more times as near to G^a as to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa.*

PUPA

Pupa (fig. 17, F) about 16 to 18 mm. long and 5 to 5.5 mm. broad, coarsely sculptured throughout, maxillary palpi not visible, labrum not emarginate, prespiracular callus absent on prothorax, abdominal segments coarsely pitted and sculptured throughout, spiracles very small, narrow, cremaster a pair of heavy, divergent spines set on a conical process.

Life History

EGG STAGE

Table 31.—*Duration of egg stage in Polia legitima*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Aug. 29, 1917	Sept. 3, 1917	5	70.9	Sept. 10, 1917	Sept. 17, 1917	7	72.4
Sept. 5, 1917	Sept. 10, 1917	5	74.9	Sept. 12, 1917	Sept. 18, 1917	6	75.5
Sept. 8, 1917	Sept. 15, 1917	7	65.2				

LARVAL STAGE

Larvae that hatched on the night of September 3, 1917, were in the last instar on September 29, indicating an active larval stage of not more than four or five weeks. This remarkably rapid larval growth is in marked contrast to the extended pupal period.

PUPAL STAGE

The pupal stage occupies about 10 months. Pupae formed on several dates between October 10 and 22, 1914, produced moths between August 4 and 27, 1915. A similar period was occupied in 1915–16.

Parasites

The writer has found a single larva of this species which had been killed and altered to a woody consistency by a fungous parasite determined by Speare as a species of Cordyceps. Chittenden (*13*) records *Sporotrichum minimum* Speg. and possibly a species of Verticillium as parasites on larvae.

THE PINK-BACKED CUTWORM, POLIA MEDITATA GRT.

Distribution

Polia meditata is reported along the Atlantic coast from New Hampshire to North Carolina and westward to Tennessee, Illinois, Missouri, Kansas, and South Dakota. It is also said to occur in Canada. Larvae have been examined from Barlow, Mo.; Clarksville and Hixson, Tenn.; and Richmond and South Boston, Va.

Food Plants and Habits

The known food plants include tobacco, clover, Solidago, *Aster ericoides*, bluegrass, and *Andropogon virginicus*.

These larvae prefer a warm, sunny location supporting a winter growth of weeds and having a suitable cover of weed litter or fallen leaves. The writer has found them common in March under leaves on a warm hillside among roadside weeds, although they are uncommon in fields and, owing to the early date at which they cease activity, only an occasional straggler has been found injuring tobacco. This species partakes of the protective coloration with which all the species of Polia seem to be endowed in one form or another. It does not normally burrow in the soil, but lies extended along some object on the ground or in the rubbish or humus covering the soil.

Seasonal History

This is a single-brooded species. The winter is passed as larvae in third and fourth instars. A few of these begin to become mature early in February and by the middle of March nearly all are in the last instar. By the last of March these have begun to enter aestivation and nearly all of the larvae are in this condition by about the middle of April, although rare stragglers extend the period of larval activity until the latter part of May. These larvae spend the summer in felted cells of silk and soil slightly beneath the surface of the ground and begin pupating early in August. Moths begin to emerge early in September and continue in flight in small numbers as late as the latter part of October. Eggs from these produce the overwintering larvae.

Forbes (*26*) found larvae in Illinois from February 28 to May 22 in meadows and grassland. Larvae taken May 22 had entered the soil previous to July 11 and moths appeared some time between August 1 and August 10. Norman (*51*) found the moths not uncommon at Saint Catharines, Ontario, August 11. It would seem probable that this is another species in which the emergence in the North is earlier than in Tennessee, as discussed under *Feltia ducens*.

Description of Stages

ADULT (PL. 3, C)

Rather uniformly fuscous more or less tinged with brown and irrorate with bluish-white scales. The usual spots and lines often nearly or quite obsolete. Hind wings fuscous, paler toward the base. Wings beneath with a mixture of pale and dark scales sometimes tinged with reddish. Expanse from about 1 inch to slightly less than 1½ inches.

EGG

The egg is white, circular in outline, oval in profile, slightly larger at the base, with the micropylar area concave, 0.67 mm. high, 0.50 mm. broad at base, and 0.32 mm. broad at apex, covered with rather close, regular, hexagonal, thick-walled reticulation, with ribs developed only near the apex. The second day after deposition a pinkish girdle and micropylar splotch appear. A moth in confinement deposited about 100 eggs on the night of September 10, 1910, and a moth dissected September 24, 1919, contained about 250 eggs, 53 of which were nearly mature.

LARVA

This is a dusky larva, suffused, particularly on the dorsum posteriorly, with pinkish, with a segmental series of diamond-shaped infuscated spots on the dorsum at least posteriorly and closely flecked with white below the spiracles. The skin is finely pavement-granulose and the adfrontal sutures terminate distinctly before reaching the occipital foramen.

First instar.—Head 0.32 mm. broad. Body about 2.2 mm. long and 0.43 mm. broad; slightly narrowed posteriorly; skin set with very small isolated granules; white; head shield brown obscurely flecked with brown dorsally. Cervical shield brownish fuscous. Anal shield fuscous. Setigerous tubercles large, conical, dark fuscous, of about equal size, their setae long and very strongly capitate. Prolegs clavate, the crochets set in a hood, functional on abdominal segments 5, 6, and 10. The above description was drawn up from very young larvae and there is probably some pigmentation of the skin later in the instar.

Second instar.—Head 0.47 to 0.50 mm. broad. Body about 2.2 to 5.7 mm. long; skin set rather closely with minute blunt tubercles; general color brownish tinged with fuscous and ferruginous, with several longitudinal white lines, the supraspiracular broadest. Cervical shield infuscated brown, darker than the head shield. Anal shield dark fuscous margined with white. Head shield pale infuscated brown. Setigerous tubercles rather prominent, dark fuscous, their setae strongly capitate. Functional prolegs on abdominal segments 5, 6, and 10.

Third instar.—Head 0.67 to 0.72 mm. broad. Body about 5 to 10 mm. long; skin closely set with flat granules giving it a transversely striate appearance; general color dirty brown tinged with pink, dorsal area pinkish ferruginous and whitish including a dark-brown segmentally constricted band, subdorsal pale band mottled with ferruginous and margined with yellowish below, supraspiracular area pale fuscous, including the usual pair of submedian pale lines, subspiracular band pale with ferruginous center, below this a mixture of pinkish, ferruginous, and whitish. Cervical and anal shields concolorous with adjacent parts. Head shield ground color dusky brown, closely, indistinctly flecked with darker. Setigerous tubercles prominent, corrugated, fuscous, their setae capitate. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10.

Fourth instar.—Head 1 to 1.1 mm. broad. Body about 7 to 10 mm. long; skin set closely with flat granules; dorsal area ferruginous tinged with pink, including a dark fuscous segmentally constricted band flecked with paler and including a broken median pale line, subdorsally a pale band tinged with ferruginous and margined below with whitish or sulphur yellow, the supraspiracular band prominent, sinuous, sooty black, ill-defined below and replaced on the thorax by a pale band, just below the spiracles a pale band flecked with ferruginous. Cervical shield concolorous with adjacent parts, with a narrow median and broader subdorsal pale lines. Head shield dusky brown, with a distinct darker coagulate reticulation. Setigerous tubercles prominent, dark fuscous, their setae rather short, stout, and strongly capitate. Anal shield pale fuscous with two broad subdorsal pale lines. Legs nearly black.

Fifth instar.—Head 1.6 to 1.7 mm. broad. Body about 16 to 20 mm. long; skin closely granulose; dorsal area brownish more or less suffused with fuscous and including a fuscous median area segmentally constricted to form a series of rhomboidal markings at least posteriorly and including an indefinite pale line, subdorsally a broken, canary-yellow line, the supraspiracular band fuscous intensified and sinuate on its dorsal margin and fading out on the thorax, posteriorly and ventrally, venter an equal mixture of pinkish and whitish, no subspiracular pale band. Cervical shield dark fuscous, shining, the median and broader subdorsal lines pinkish. Anal shield rather small, declivous, pale fuscous with a slender median line and subdorsal bands yellowish. Head shield ground color brown with fuscous submedian arcs and fuscous reticulation, sometimes nearly uniformly infuscated. Setigerous tubercles small, flat, shining, more or less margined with whitish. Legs fuscous.

Sixth instar (pl. 8, B, I).—Head 2.3 to 2.5 mm. broad. Body about 25 to 30 mm. long and 5 mm. broad; abdominal segments of about equal width throughout; skin finely pavement-granulose; general color a dark drab especially anteriorly with more or less pinkish especially posteriorly, dorsal area pale with an included series of infuscated rhomboidal or ovoid markings at least posteriorly, supraspiracular area fuscous, intense dorsally on the abdomen excepting at the juncture of the segments and fading out below, venter sordid closely flecked with white especially in an area just below the spiracles. Cervical shield shining, usually deeply infuscated on all its margins, with three pale pinkish stripes. Anal shield with two broad pale lateral stripes. Head shield ground color pale yellowish with submedian arcs and the heavy reticulation fuscous, the adfrontal sutures terminating distinctly before reaching the occipital foramen. Setigerous tubercles I and II of abdomen rather small, other tubercles large, conspicuous, their setae minute. Spiracles black. Legs pale brownish. The anterior pair of prolegs each with about 12 crochets.

Mouth parts: Mandibles of the ordinary type. Hypopharynx much as in *Agrotis ypsilon*, the lingua occupying somewhat less than half the length of the part and bare medially, with short heavy spines in the premaxillulary area, the blade of the maxillullae with about 15 or 20 slender, pointed, isolated teeth. Spinneret more than three times as long as broad, tapering slightly to the truncated tip. Labial palpi with the segments in the proportion of 19, 2, and 4.

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. A^a somewhat nearer to A^2 than to A^3. A^a about twice as near to A^2 as to P^a. P^1 equidistant from Adf^1 and Adf^2 or slightly nearer to Adf^1. P^1 slightly below the level of Adf^2. Punctures F^a somewhat below the level of setae F^1. O^2 somewhat nearer to A^3 than to L^1. O^2 variable in relation to O^1 and A^3 but usually somewhat nearer to A^3. SO^3 nearer to O^3 than to G^1. G^1 slightly nearer to O^3 than to SO^3. G^a variable, equidistant from G^1 and O^3 or somewhat nearer to G^1. Arrangement of setae and punctures otherwise as in *Feltia annexa.*

PUPA

Pupa (fig. 17, D) about 16 mm. long and 5.5 mm. broad, tapering subequally both anteriorly and posteriorly from about midway of the length, maxillary palpi not visible, labrum not emarginate, prespiracular callus absent on prothorax, movably linked abdominal segments with small round punctures, spiracles narrow, directed laterally, cremaster without accessory spinules, spines long, slender, set on an indefinite process which is coarsely rugulose.

LIFE HISTORY

EGG STAGE

TABLE 32.—*Duration of egg stage in Polia meditata*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Sept. 22, 1910	Sept. 30, 1910	8	61.8	Sept. 29, 1917	Oct. 20, 1917	21	57.3
Sept. 23, 1910	Oct. 3, 1910	10	61.2	Sept. 23, 1917	do	27	59.0
Sept. 24, 1917	Oct. 4, 1917	10	63.1	Oct. 7, 1916 [1]	Oct. 24, 1916	17	58.9
Do	Oct. 7, 1917	13	61.2	Sept. 30, 1917	Oct. 25, 1917	25	54.7
Sept. 26, 1916	Oct. 8, 1916	12	63.1	Sept. 24, 1917	do	31	56.7
Sept. 23, 1917	Oct. 10, 1917	17	60.2	Oct. 7, 1916	Oct. 26, 1916	19	57.9
Oct. 1, 1916	Oct. 14, 1916	13	64.9	Oct. 6, 1917	Oct. 26, 1917	20	53.2
Oct. 3, 1916	Oct. 15, 1916	12	64.8	Oct. 9, 1916	Oct. 29, 1916	20	56.1
Sept. 26, 1917	do	19	57.3	Oct. 11, 1916	do	18	56.3
Sept. 23, 1917	do	22	58.3	Oct. 4, 1917	do	25	53.7
Oct. 5, 1916	Oct. 16, 1916	11	65.2	Do	Nov. 2, 1917	29	49.5
Sept. 26, 1917	Oct. 18, 1917	22	59.2	Oct. 5, 1917	Nov. 3, 1917	29	50.6
Sept. 23, 1917	do	25	59.8	Do.[1]	Nov. 4, 1917	30	50.6
Sept. 28, 1917	do	20	58.5	Oct. 11, 1917	Nov. 10, 1917	30	50.9
Sept. 30, 1917	do	18	58.0	Oct. 13, 1917	Nov. 15, 1917	33	51.4
Do	Oct. 20, 1917	20	57.1				

[1] 2 lots.

It will be noted that the eggs deposited on the night of September 23, 1917, continued to produce larvae over a period of 10 days.

LARVAL STAGE

Larvae which hatched on the night of October 1, 1910, were in the last instar March 15, 1911. Allowing two additional weeks for the completion of this instar, we obtain an active larval period of nearly 6 months. The aestivating stage, on the average, has a duration of about 4 months, giving a total of about 10 months which this insect passes in the larval stage.

PUPAL STAGE

A pupa formed August 20, 1916, produced the moth September 15, giving a pupal stage of 26 days; another formed August 23, 1916, produced the moth September 26, giving a pupal stage of 30 days; and several less definite records indicate a similar duration of the pupal stage.

Predators

A mature larva of this species was taken March 12, 1917, in the grasp of a spider, determined by Shoemaker as *Thanatus lycosoides* Emerton. The writer has taken another spider, *Xysticus nervosus* Banks, feeding upon a larva. He has not bred a parasite from this not uncommon species.

THE BRISTLY CUTWORM, POLIA RENIGERA STEPH.

Distribution

This species occurs throughout the United States east of the Mississippi River, and its western range includes North Dakota, Nebraska, Kansas, Colorado, and New Mexico. It is also found in Canada and Europe. The writer has never received either moths or larvae from Texas, although D. C. Parman, during 1915, 1916, 1917, and 1918, made numerous sendings both of larvae and of moths taken in bait traps from Uvalde; and J. D. Mitchell also sent several collections of larvae from Victoria, Tex. It has been reported as abundant in Louisiana, although Jones (*40*) does not mention it, and it is one of the commoner cutworms at Clarksville, Tenn.

Food Plants

The known food plants include alfalfa, *Aster ericoides*, cabbage, chicory, chickweed, clover, comfrey, corn, cottonweed leaves, dandelion, grasses, *Plantago major*, *P. lanceolata*, *Rumex crispus*, tobacco, and turnip. The larva is not uncommon in tobacco fields at Clarksville, but this species is not important with regard to the tobacco crop.

Food and Larval Habits

The writer has found this species most abundant in old clover fields which have a cover of litter of the sort attractive to the larvae of *Feltia subgothica* and *F. ducens*. In such situations these species have much the same habits, and *P. renigera* is sometimes almost as abundant as the other two together. The larvae also occur in smaller numbers in pastures and waste land.

The coloration of this larva blends perfectly with the dead grass and weed litter with which it is normally associated, and to add to the protection provided by its markings the larva lies extended upon and closely appressed to the object upon which it rests and clings so tenaciously that the litter may be threshed about without dislodging the larva. When disturbed away from the support it usually assumes a rigidly extended attitude and maintains this attitude even though it is gently rolled from side to side with a finger. This species is much less subterranean in habit than most other cutworms, and the rigid selection practiced by sharp-eyed birds and other enemies seems to have produced a combination of coloration and posture which is remarkably effective.

Seasonal History

This is a two-brooded species. The winter is passed as larvae in the third and fourth instars. A few of these larvae become of mature size in the latter part of March and nearly all are mature early in April. Pupation begins early in April and by the middle of the month the larvae are transforming in numbers, nearly all having pupated by the end of the first week in May, although stragglers extend the period of transformation to the latter part of May. Moths begin to appear the last of April and continue to emerge until beyond the middle of June, a few stragglers continuing on the wing as late as the 1st of July. The larvae produced by this brood, after an unusually prolonged active period, begin pupating the latter part of July. Moths begin emerging early in August and continue to emerge until early in October, continuing on the wing until early in November. In trap lights the main catch of moths is made between the middle of September and the end of the first week in October.

Forbes (*26*, *28*) states that the species is two-brooded and that the winter is passed in the larval stage. These larvae are most destructive the latter part of April and early in May and first-brood moths appear from the latter part of May until the middle of July, being most abundant the latter part of May and early in June. Moths of the second brood appear about the middle of August and continue through September and into early October. Gillette (*34*) has found the moths abundant in Iowa in June and again the latter part of August. Norman (*51*) states that the moths were very common in Ontario and were taken from June 23 to October. Garman (*32*) has found the species two-brooded in Kentucky, the first-brood moths occurring from April 4 to June 29 and the second-brood moths from August 8 to September 24.

Description of Stages

ADULT (PL. 3, B)

Forewings dark brown more or less suffused with pinkish especially subapically, with the reniform spot, a spot at the base, and another near the hind angle, green, the reniform usually conspicuously margined with white posteriorly and surrounded by a dark shade, the claviform spot black, the hind wings white, more or less infuscated. Expanse from about 1 inch to somewhat less than 1¼ inches.

EGG

The egg is white, circular in outline, bluntly subconical in profile, 0.70 mm. broad and 0.51 to 0.55 mm. high, with about 30 slender, abruptly elevated ribs arranged with great uniformity, neither branching nor coalescing and rarely failing to reach the micropylar area where they terminate abruptly, with the micropylar area concave, elevated in the center and regularly reticulate. The second day after deposition a belt and micropylar splotch of reddish brown appear.

In confinement the eggs have been tucked away singly or a few together on small grass roots, within the inrolled portions of dead grass blades, and on other rubbish. A dead unopened dandelion head contained 15 eggs well within it. Eggs were not deposited upon green grass growing in the cages. One moth deposited 112 eggs May 17, 1910, and a moth taken at a light May 23, 1915, deposited a total of 239 eggs during the following nine days.

LARVA

In this larva the general color is a light gray with a segmental series of dark diamond-shaped or ovoid figures on the dorsum at least posteriorly and with the upper half of the supraspiracular area forming a continuous black stripe; the skin is set with coarse, isolated, subconical granules; the setigerous tubercles of the dorsum are subconical and bear stout setae; the head shield is coarsely granulose; and the adfrontal sutures terminate distinctly before reaching the occipital foramen.

First instar.—Head 0.32 to 0.35 mm. broad. Body about 2.2 to 5.5 mm. long and 0.45 mm. broad; tapering slightly posteriorly; skin set, especially on the dorsum, with very small isolated granules; ferruginous brownish, especially posteriorly with seven pale lines, the subspiracular broadest. Cervical and anal shields dark fuscous, anal shield entire. Head shield pale fuscous brown without arcs or reticulation. Setigerous tubercles large, fuscous, of about equal size, their setae fuscous brown, long, bristly, curved, and strongly capitate. Spiracles protuberant. Functional prolegs on abdominal segments 5, 6, and 10. Legs fuscous brown.

Second instar.—Head 0.45 to 0.50 mm. broad. Body about 4 to 5.5 mm. long; skin strongly granulose; general color a mixture of brown, ferruginous, and fuscous growing darker posteriorly, with seven pale lines, the subspiracular with a distinct ferruginous center, dorsal area uniform fuscous. Anal shield concolorous with adjacent parts. Cervical shield dark fuscous. Head shield dark fuscous. Setigerous tubercles large, fuscous, corrugated, their setae long, coarse, nearly straight, strongly capitate, those on the thorax directed anteriorly, those on the abdomen directed anteriorly on tubercle I and posteriorly on tubercle II, all directed backwards on the posterior extremity. Spiracles protuberant. Legs pale fuscous. Prolegs pale fuscous, functional on abdominal segments 3, 4, 5, 6, and 10.

Third instar.—Head 0.65 mm. broad. Body 6 to 7.5 mm. long; skin densely granulose; general color pale gray, dorsal area pale, including a median dark fuscous-brown, segmentally constricted stripe bearing a distinct continuous pale line, subdorsal band pale with a brownish-ferruginous line a little above the center and a pale ferruginous line below the center, supraspiracular area nearly black with a pale median line, subspiracular band pale, medially pale ferruginous, venter pale fuscous flecked with white. Cervical shield dark fuscous. Head shield very dark, appearing black. Setigerous tubercles brownish fuscous, their setae long, bristlelike, and capitate. Spiracles protuberant.

Fourth instar.—Head 0.80 to 0.96 mm. broad. Body about 8 to 12 mm. long. This instar is, in all other details, like the fifth instar.

Fifth instar.—Head 1.2 to 1.5 mm. broad. Body about 12 to 20 mm. long and 3.5 mm. broad; slightly broadest through first four abdominal segments; skin granules as in mature larva; coloration, including that of the anal, cervical, and head shields, legs and prolegs, as in the mature larva, usually with more ferruginous in the subdorsal and subspiracular stripes.

Sixth instar (pl. 8, H).—Head 2 to 2.1 mm. broad. Body about 20 to 30 mm. long and 4.5 mm. broad; very slightly broadest through the first four abdominal segments, the posterior extremity blunt; skin set with coarse, isolated, somewhat retrorse, subconical granules (fig. 4, I); general color pale grayish, dorsal area pale including an infuscated band constricted at the juncture of the segments to form a series of rhomboidal or ovoid markings, subdorsally an inconspicuous pale stripe more or less flecked with ferruginous or brownish, upper half of supraspiracular area forming a prominent black stripe continuous even on the cervical shield and thorax, lower half of supraspiracular area dilute fuscous much flecked with white, the median pair of pale lines fused to form a narrow pale stripe, just below the spiracles a well-defined pale band, venter sordid much flecked with white. Anal shield fuscous with a narrow median line and pair of broad subdorsal stripes pale. Cervical shield dark fuscous. Head shield coarsely granulose, ground color grayish brown, the submedian arcs fuscous and almost entirely obscuring the ground color dorsally, the adfrontal sutures terminating distinctly before reaching the occipital foramen. Setigerous tubercles inconspicuous, pale excepting a fuscous ring about the base of the seta, I to IV of about equal size, the dorsal tubercles subconical, their setae stout, those on tubercle I of abdomen directed anteriorly, on II posteriorly. Spiracles nearly black. Legs fuscous. Prolegs pale, the anterior pair each with about 7 to 13 crochets, shields, except on anal prolegs, dark fuscous.

Mouth parts: Mandibles of ordinary type. Hypopharynx with lingua occupying slightly less than half the length of the part, clothed rather closely throughout with slender, appressed, retrorse spinules arranged in broken transverse rows, somewhat heavy spines on the premaxillulary area, maxillulae set closely with small slender spinules, blade of maxillulae with several groups consisting of two to seven very small, slenderly triangular, flat teeth, the gorge bare except anteriorly. Spinneret about three times as long as broad, tapering slightly to the truncate apex, usually with three black lines. Labial palpi with the segments in the proportion of 21, 4, and 8.

Setae and punctures of head: A^a about twice as near to A^2 as to A^3. P^b, A^2, and A^1 not in a straight line. Punctures F^a slightly below the line of setae F^1. Interspace E^1 to E^2 scarcely greater than F^1 to F^a. SO^3 equidistant from G^1 and O^3 or somewhat nearer to O^3. G^1 decidedly nearer to O^3 than to SO^3. G^a distinctly nearer to G^1 than to O^3. G^1 more than twice as near to G^a as to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa.*

PUPA

Pupa (fig. 17, E) about 12 to 14 mm. long and 4 to 5 mm. broad, maxillary palpi not visible, labrum not emarginate, prespiracular callus absent on prothorax, punctures on movably linked abdominal segments coarse, round, cremaster without accessory spinules, spines long, stout, convergent, set on a distinct subconical process which is very coarsely rugulose.

LIFE HISTORY

TABLE 33.—*Length of generations in Polia renigera*

Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
		Days	°*F.*		*Days*	°*F.*		*Days*	°*F.*	*Days*	°*F.*
May 6, 1917	May 20, 1917	14	58.7	July 21, 1917	62	71.9	Aug. 6, 1917	16	78.6	92	71.1
Do	do	14	58.7	July 22, 1917	63	72.0	Aug. 8, 1917	17	78.6	94	71.2
Do	do	14	58.7	July 26, 1917	67	72.3	Aug. 9, 1917	14	78.8	95	71.3
Do	do	14	58.7	July 24, 1917	65	72.1	Aug. 10, 1917	17	78.1	96	71.2
Do	do	14	58.7	July 27, 1917	68	72.3	Aug. 13, 1917	17	76.9	99	71.2
Do	do	14	58.7	July 28, 1917	69	72.5	do	16	76.7	99	71.2
Do	do	14	58.7	do	69	72.5	Aug. 15, 1917	18	76.6	101	71.3
Do	do	14	58.7	July 29, 1917	70	72.6	Aug. 17, 1917	19	76.1	103	71.3
Do	do	14	58.7	Aug. 5, 1917	77	73.2	Aug. 22, 1917	17	74.5	108	71.5
Do	do	14	58.7	Aug. 6, 1917	78	73.2	Aug. 24, 1917	18	73.9	110	71.5
May 29, 1914	June 4, 1914	6	78.8	Aug. 20, 1914	77	82.1	Sept. 8, 1914	19	77.8	102	81.1
May 28, 1914	do.[1]	6	78.6	Aug. 23, 1914[2]	81	82.1	do	16	72.5	103	80.4
May 29, 1914	do	6	78.8	do	80	82.1	Sept. 10, 1914	18	76.2	104	80.9
Do	do	6	78.8	Aug. 24, 1914	81	82.2	Sept. 11, 1914	18	75.6	105	80.9
Do	do	6	78.8	Aug. 22, 1914	79	82.1	do	20	76.6	105	80.9
June 3, 1916	June 12, 1916	9	70.5	do	71	77.5	Sept. 11, 1916	20	73.9	100	76.1
May 29, 1914	June 4, 1914	6	78.8	Aug. 24, 1914	81	82.2	Sept. 12, 1914	19	75.2	106	80.8
May 23, 1916	May 30, 1916	7	79.8	Aug. 26, 1916[3]	88	76.5	Sept. 12, 1916	17	74.3	112	76.4
May 30, 1915	June 5, 1915	6	72.8	Aug. 26, 1915	82	77.1	Sept. 12, 1915	17	74.6	105	76.4
Do	do	6	72.8	Aug. 29, 1915	85	76.9	Sept. 13, 1915	15	76.1	106	76.6
June 2, 1916	June 11, 1916	9	71.2	Aug. 31, 1916	81	76.7	Sept. 18, 1916	18	71.9	108	75.4
May 23, 1916	May 30, 1916	7	79.8	Sept. 5, 1916	98	76.1	do	13	70.0	118	75.6
June 8, 1914	June 14, 1914	6	85.5	Sept. 2, 1914	80	81.3	Sept. 19, 1914[4]	17	73.1	103	80.2
June 2, 1916	June 11, 1916	9	71.2	Sept. 4, 1916	85	76.6	Sept. 19, 1916	15	70.0	109	75.2
May 24, 1916	May 31, 1916	7	79.5	Sept. 1, 1916	93	76.1	Sept. 20, 1916	19	70.3	119	75.4
Do	do	7	79.5	Sept. 4, 1916	96	76.2	Sept. 22, 1916	18	68.6	121	75.3
June 3, 1916	June 12, 1916	9	70.5	Sept. 2, 1916	82	76.7	do	20	69.3	111	74.8
May 24, 1916	May 31, 1916	7	79.5	do.[3]	94	76.1	do	20	69.3	121	75.2
May 31, 1916	June 8, 1916	8	73.0	Sept. 3, 1916	87	76.4	do	19	68.9	114	74.9
June 2, 1916	June 11, 1916	9	71.2	Sept. 4, 1916	85	76.6	Sept. 23, 1916	19	68.1	113	74.7
Do	do	9	71.2	do	85	76.6	Sept. 25, 1916	21	67.6	115	74.5
June 3, 1916	June 12, 1916	9	70.5	Sept. 5, 1916	85	76.6	do	20	67.1	114	74.5
May 23, 1916	May 30, 1916	7	79.8	Sept. 4, 1916	97	76.1	do	21	67.6	125	74.8
June 3, 1916	June 12, 1916	9	70.5	do	84	76.7	do	21	67.6	114	74.5
May 31, 1916	June 8, 1916	8	73.0	Sept. 7, 1916	91	76.6	Sept. 26, 1916	19	66.1	118	74.7
May 24, 1916	May 31, 1916	7	79.5	Sept 4, 1916	96	76.1	do	22	67.9	125	74.8
May 31, 1916	June 8, 1916	8	73.0	Sept. 7, 1916	91	76.6	Sept. 27, 1916	20	66.5	119	74.7

[1] 6 a. m. [2] 2 individuals. [3] Forenoon. [4] Afternoon.

PREOVIPOSITION PERIOD

Moths which emerged on the night of May 16, 1913, deposited fertile eggs on the night of May 20, four days after emergence.

EGG STAGE

TABLE 34.—*Duration of egg stage in Polia renigera*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
May 3, 1917	May 19, 1917	16	56.4	June 3, 1916	June 12, 1916	9	70.5
May 4, 1917	May 20, 1917	16	57.4	June 8 1914	June 14, 1914	6	85.5
May 6, 1917	do	14	58.6	June 9, 1917	June 18, 1917	9	65.8
May 17, 1910	May 27, 1910	10	67.5	June 11, 1917	June 20, 1917 [3]	9	67.3
May 18, 1913	May 27, 1913	9	67.4	June 13, 1917	June 22, 1917 [3]	9	67.7
May 18, 1910	May 28, 1910	10	69.1	Sept. 12, 1916	Sept. 24, 1916 [3]	12	61.5
May 22, 1918	May 28, 1918 [1]	6	77.6	Sept. 18, 1910	Sept. 25, 1910	7	77.4
May 19, 1910	May 29, 1910	10	68.3	Sept. 17, 1914	Sept. 25, 1914	8	72.2
May 23, 1916	May 30, 1916 [2]	7	79.8	Sept. 19, 1910	Sept. 25, 1910	6	77.4
May 24, 1916	May 31, 1916	7	79.5	Sept. 17, 1917	Sept. 27, 1917	10	67.1
May 26, 1916	June 2, 1916	7	79.7	Sept. 19, 1914	Sept. 29, 1914	10	67.2
May 28, 1914	June 3, 1914	6	78.7	Sept. 19, 1917	Sept. 30, 1917	11	65.4
May 29, 1914	June 4, 1914 [3]	6	78.9	Sept. 20, 1917	Oct. 3, 1917	13	63.4
May 28, 1916	June 5, 1916 [4]	8	75.6	Sept. 28, 1915	Oct. 12, 1915	14	58.7
May 30, 1915	June 5, 1915	6	72.8	Oct. 3, 1916	Oct. 14, 1916 [1]	11	64.4
May 31, 1914	June 6, 1914	6	78.7	Oct. 1, 1915	Oct. 16, 1915	15	59.3
May 31, 1916	June 8, 1916	8	73.1	Oct. 5, 1915	Oct. 19, 1915	14	59.5
June 2, 1916	June 10, 1916	8	71.9	Nov. 2, 1916	Dec. 3, 1916	31	46.9
Do	June 11, 1916	9	71.2				

[1] 3 sets of eggs. [2] 4 sets of eggs. [3] 2 sets of eggs. [4] 6 sets of eggs.

LARVAL STAGE

As shown in Table 33, the duration of the larval stage in the second brood is 63 to 97 days, with the usual period between 65 and 85 days. The overwintering larval stage requires about 7 months or somewhat more. Larvae that hatched on September 10, 1910, pupated early in the following May.

PUPAL STAGE

The length of the pupal stage in the second brood, as given in Table 33, ranges from 16 to 22 days, with the usual period between 17 and 20 days. The length of the pupal stage in the first brood is given in Table 35.

TABLE 35.—*Duration of pupal stage in Polia renigera*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Apr. 4, 1913	May 4, 1913	30	60.8	Apr. 25, 1913	May 20, 1913 [1]	25	62.8
Apr. 9, 1910	May 10, 1910	31	57.0	Apr. 23, 1916	May 20, 1916	27	62.5
Apr. 19, 1913	May 11, 1913 [1]	22	66.1	Apr. 24, 1916	do	26	62.6
Apr. 13, 1911	May 12, 1911 [2]	29	62.2	Apr. 21, 1916	do	29	62.3
Apr. 14, 1916	May 12, 1916	28	62.3	Apr. 24, 1916	May 21, 1916	27	62.8
Apr. 19, 1913	May 13, 1913	24	66.2	Apr. 25, 1916	do	26	62.1
Apr. 14, 1916	May 13, 1916	29	62.5	Apr. 22, 1916	do	29	62.6
Apr. 19, 1913	May 14, 1913 [3]	25	62.8	Apr. 30, 1916	May 22, 1916	22	65.3
Apr. 15, 1916	May 14, 1916	29	63.0	Apr. 28, 1916	May 23, 1916	25	65.1
Apr. 17, 1916	do	27	62.9	Apr. 30, 1916	do	23	65.5
Apr. 16, 1916	May 15, 1916 [3]	29	63.0	May 2, 1916	do	21	65.5
Apr. 17, 1916	do	28	63.2	Apr. 19, 1910	May 24, 1910	35	62.0
Apr. 24, 1913	May 16, 1913	22	63.5	May 2, 1916	May 24, 1916 [3]	22	65.9
Apr. 23, 1913	do	23	63.4	May 6, 1913	May 25, 1913	19	67.3
Apr. 17, 1916	May 16, 1916	29	63.1	May 2, 1913	do.[4]	23	66.4
Apr. 19, 1916	May 17, 1916	28	62.8	May 5, 1916	May 25, 1916	20	67.4
Apr. 20, 1916	do	27	62.5	May 6, 1916	do	19	67.4
Apr. 25, 1913	May 18, 1913	23	63.3	May 14, 1911	May 29, 1911	15	77.7
Apr. 23, 1913	do	25	62.5	May 21, 1910	June 12, 1910	22	66.3
Apr. 24, 1913	do	24	62.9	Aug. 11, 1910	Aug. 29, 1910	18	75.2
Apr. 23, 1916	May 18, 1916	25	62.9	Aug. 1, 1910	Aug. 17, 1910	16	74.4
Apr. 19, 1916	May 19, 1916	30	62.4	Aug. 27, 1910	Sept. 13, 1910	17	78.7
Apr. 28, 1913	May 20, 1913	22	62.3				

[1] 3 individuals. [2] 4 individuals. [3] 2 individuals. [4] 5 individuals.

Parasites

On April 11, 1916, a selection of 100 larvae of this species was made, comprising a representative series with regard to size, and these were reared under good sanitary conditions in glass tumblers. The various sources of mortality in these larvae are indicated below:

Moths emerged	26
Larvae parasitized	47
By Berecyntus sp	44
By Amblyteles sp	2
By a dipteron	1
Died pupating	1
Died as pupae	14
Died as larvae	12

There was in this case a mortality of 74 per cent, 47 per cent being due to parasites.

In 1921, 147 larvae were collected when nearly mature and reared in tin boxes with unsterilized field earth. Mortality was as follows:

Moths emerged		91
Parasitized		44
Insects:		
(*Copidosoma*) *Berecyntus celaenae* How	35 larvae.	
Nematode:		
Mermis sp	1 larva.	
Disease:		
Sorosporella uvella (Krass.) Gd	2 larvae.	
Beauveria sp	2 larvae.	
Bacterial disease (?)	4 larvae.	
Died as larvae without apparent cause		6
Died as pupae without apparent cause		4
Injured		2

The host larvae were killed by (*Copidosoma*) *Berecyntus celaenae* How., shortly after they had formed cells preparatory to pupation. Larvae collected from April 1 to 27 produced emerging parasites from May 10 to 29, a period of from 25 to 32 days elapsing between the death of the host and emergence of the parasites. It is a strange fact that larvae parasitized by this species are often noticeably larger than the average. K. B. McKinney counted the number of parasites in 30 host larvae and found a minimum of 420 and a maximum of 1,585, the average being 822. The skin of the host is distended after death by the multitude of parasitic larvae or pupae within it.

The specimens of Amblyteles emerged May 21 and 24 from pupae formed April 19. *Chaetogaedia analis* V. d. W. has been bred by the writer from larvae from South Boston, Va. A small larva, determined by Böving as probably a species of Pterostichus, was taken feeding on a larva of *renigera* May 10, 1920. Muesebeck (*48*) records *Apanteles forbesi* Vier. from this species, and the writer obtained this parasite from larvae in May, 1921. He has also taken a spider, determined by Shoemaker as *Lycosa fatifera* Hentz, feeding on a larva of *renigera* in the field.

THE SHIELD-MARKED CUTWORM, PARASTICHTIS BICOLORAGO GN.

Distribution

The writer has examined larvae from Clarksville, Tenn., South Boston, Va., and Sioux City, Iowa, and has seen moths from New York, Pennsylvania, District of Columbia, and Texas. The species is also reported from Canada.

Food Plants

The larvae are known to feed upon tobacco, *Rumex crispus*, soft maple (*Acer saccharinum*), and cabbage.

Larval Habits

Larvae have been taken in small numbers in dry upland, but they occur much more abundantly in mud flats along the river, where the cool, shaded soil is periodically overflowed and is barren, except for a sparse growth of moss, aster sprouts, plantain, and seedling maples and elms, overspread by large trees of maple, elm, sycamore, or mulberry. The seedlings have given no evidence of feeding, but it is probable that the larvae feed upon the foliage of maple trees, as they are such expert climbers that they readily scale the side of a glass tumbler and they feed freely on maple leaves in confinement. The larvae are found on the surface of these mud flats beneath chips, bits of driftwood, and fallen leaves. The long aestivation period is spent in tough silken cocoons in a cell buried one-fourth inch or less in the soil and usually provided with an exit hole to the surface. The cocoons, tough in the spring, become rotten and easily penetrable before time for the emergence of the moth, and some even attain such a poor state of repair that a light new cocoon is spun late in the season within the old one.

This species has proved injurious on several occasions to tobacco-plant beds grown near mud flats, and in these beds the larvae have shown a well-developed cutting habit.

Seasonal History

Larvae hatch the latter part of January and in early February and most of them enter the soil for aestivation the last of April and very early in May, a few stragglers occurring abroad as late as May 18. They spend the summer in heavy silken cells in the soil and begin pupating the latter part of August. Moths begin to emerge the latter part of September and continue to emerge until the latter part of October, continuing on the wing until in December, and deposit the eggs which hatch the following spring.

Description of Stages

ADULT (PL. 3, L)

Forewings and thorax buff tinged with purplish, a median transverse shade, a subapical shade, and a spot at the lower margin of reniform, darker. About midway between the reniform spot and the apex of the wing, representing the posterior transverse line, a transverse venular series of small dark spots, beyond which the veins are darker but covered by pale scales; subterminal line yellow, distinct, extended as dashes between the veins to the margin of wing. Hind wings yellowish washed with fuscous. Expanse from somewhat less than to somewhat more than 1½ inches.

EGG

The egg is white, circular in outline, in profile distinctly narrowing on the apical half, 0.58 to 0.62 mm. broad and 0.50 mm. high, with about 30 strong, distinctly sinuate ribs and many distinct transverse lines. In one or two days after deposition the egg becomes entirely iridescent pale chocolate brown.

LARVA

The contour of the body, which gradually increases in width from the head to the eighth abdominal segment, and the series of infuscated brown scutate markings in the dorsal area, will serve to distinguish this species. Freshly collected larvae are remarkable in that they give off a strong odor resembling that of heliotrope.

First instar.—Head 0.24 mm. broad. Body about 1.6 to 2.5 mm. long and 0.24 mm. broad at middle, tapering gradually from the prothorax posteriorly, set closely with rather fine rounded papillae, color uniform yellowish white. Head shield nearly black, the front almost reaching the occipital foramen. Prolegs on abdominal segments 3, 4, 5, 6 and 10 subequal, three or four crochets on each, hooded beneath a membrane. Setae pointed, not at all capitate, those on the dorsum less than one-fifth as long as the segment upon which they are placed, spiracles and setigerous tubercles inconspicuous, dark. Legs fuscous.

Mature larva (pl. 7, E, F).—Head 1.7 to 2 mm. broad. Body about 22 mm. long, becoming gradually broader from the head to the eighth abdominal segment; dark velvety brownish flecked with paler, and more or less suffused with purplish, dorsal area on the abdomen bearing a series of shield-shaped, deeply infuscated brown spots, having their lateral anterior margins darker and their apices directed posteriorly, the spot on ninth abdominal segment usually sagittate, the tip extending across the anal shield, a pale broken middorsal line more distinct on posterior margins of segments, just outside the anterior points of the dorsal shields a broken indefinite subdorsal line, below the spiracles a pale line more distinct and yellowish anteriorly, body below spiracles of dilute dorsal color; spiracles black; cervical shield slightly darker than the dorsal area, with three pale lines, the median narrowest; anal shield concolorous with adjacent parts with a broad dark median stripe bearing a pale line; head shield shining, ground color deep brown with submedian arcs and dense reticulation dark fuscous, sometimes nearly completely infuscated, adfrontal sutures ending on the median line before reaching the occipital sinus; setigerous tubercles of body minute, of about equal size, each set in a pale spot; legs brown, the claw with basal portion broadly rounded, but slightly, obtusely angulate. Each anterior proleg with about 12 crochets.

Mouth parts: Mandibles of ordinary type. Hypopharynx suboval broadest posteriorly; lingua occupying about one-fourth the length of the part, clothed both medially and laterally with minute, weak, appressed spinules except in the premaxillulary area which bears exceedingly heavy rather short spines that also extend into the median area; maxillulae clothed throughout with minute, weak, slender spinules, blade of maxillulae with about 20 to 25 small, flat, slender, acutely pointed, distinctly isolated teeth (fig. 11, C); gorge bare except at anterior end. Spinneret slender, about six times as long as broad and three times as long as the labial palpi (fig. 10, D) with the tip bluntly rounded. Labial palpi with the segments in the proportion of 15, 2, and 5, the papilla on the basal segment nearly or quite as long as the third segment.

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. A^2 approximately equidistant from A^a and A^1. A^2 twice as near to A^1 as to P^a. A^a decidedly nearer to A^2 than to P^a. P^1 equidistant from Adf^1 and Adf^2 or slightly nearer Adf^1. P^b, A^2, and A^1 not in a straight line. P^b decidedly nearer to P^2 than to P^1. The interspace A^2 to A^a approximately equal to P^1 to P^a. Punctures F^a distinctly below the level of setae F^1. Ocellus VI twice as near to O^1 as to O^3. O^2 slightly nearer to A^3 than to O^1. O^a less than the ocellar width removed from ocellus VI and three times as near to the ocellus as to O^3. SO^a slightly nearer to SO^3 than to SO^2. SO^3 distinctly nearer to O^3 than to G^1. G^1 somewhat nearer to O^3 than to SO^3. G^a somewhat nearer to G^1 than to O^3. G^1 twice as near to G^a as to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa (fig. 18, E, F) about 12 to 15 mm. long and 4 to 5 mm. broad, maxillary palpi visible at outer angle of eye, labrum not emarginate, prescpiracular callus absent on prothorax, punctures of movably-linked abdominal segments round, spiracles directed laterally, cremaster with two pairs of straight, hookless, accessory spinules, spines rather long, stout, directed downward, convergent, and set on an indefinite process, which is rugulose both anterior to and below the spines and bears on each side about three distinct carinae.

Life History

EGG STAGE

Table 36.—*Duration of the egg stage in Parastichtis bicolorago*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Oct. 25, 1915	Jan. 25, 1916	92	44.1	Oct. 28, 1915	Feb. 7, 1916	102	45.0
Nov. 4, 1915	Jan. 31, 1916	88	44.0	Oct. 30, 1915 [1]	Dec. 23, 1915	[1] 54	

[1] Indoors.

The eggs from which the records in Table 36 were obtained were deposited in glass tubes which were stoppered with absorbent cotton. These tubes (except one) were laid on the ground outdoors where they were wet by the snow and rain. The larvae upon hatching managed to survive in these exceedingly wet tubes under conditions to which ordinary larvae would have speedily succumbed. It may be that the eggs are normally deposited upon the occasionally inundated mud flats upon which the larvae most frequently occur and that the larva is especially fitted to take care of itself in wet surroundings. In the indoor record noted above, the eggs were kept in a warm room after December 9.

It will be noted that the eggs of this species hatch in the coldest season of the year. This maladjustment to the environment is but another example of the difficulties which beset single-brooded species as they advance southward, as discussed under " Distribution," page 3.

LARVAL STAGE

The active larval stage lasts about 3 months and the larva aestivates an additional 4 months, giving a total of about 7 months which this insect passes in the larval stage.

PUPAL STAGE

Table 37.—*Duration of pupal stage in Parastichtis bicolorago.*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Aug. 27, 1914	Sept. 20, 1914	24	74.1	Sept. 3, 1914	Oct. 9, 1914	36	70.5
Aug. 28, 1914	Sept. 29, 1914	32	69.6	Sept. 5, 1914	Oct. 7, 1914	32	70.3
Sept. 1, 1914	Oct. 6, 1914	35	70.5				

The pupal cell is made within about one-fourth inch of the surface of the soil and is usually provided with an exit hole, probably as a provision against the hardening of the soil during the long period intervening between the formation of the cell and the emergence of the moth.

Parasites and Predators

Of 72 larvae of this species, 9 were parasitized by a hymenopteron determined by Cushman as *Ophion idoneum* Vier. These occurred singly in the larvae attacked and spun black, smooth, parchmentlike cocoons with a brown median band the latter part of May, from which the adults emerged in the spring of the following year. Parasitism by this species is probably considerably higher than is here indicated, as the larvae of the moth were found to be very susceptible to desiccation only after a heavy mortality had occurred, and in digging over the mud flats it was found that half or more of the larval cells contained cocoons of this parasite in 1914. The writer has also reared *Ophion bilineatum* Say from larvae. Several puparia have been found in larval cells in the course of studies on the seasonal history of this species, and a larva pupated abortively August 18, 1914, which contained a dipterous larva, but no flies have been reared from this species. A species of Apanteles was also obtained from larvae in April, 1914, and described by Muesebeck (*48*) as *Apanteles parastichtidis*.

Out of 85 aestivating larvae dug out of the mud flats early in May, 1919, 5 had been very recently killed by predators, and some of these deaths were definitely assignable to adults of Scarites whose burrows were found to connect with the cell of the larva attacked. Numerous carabids were present in the soil, and it is probable that a high mortality is due to the activities of these predators. A few larvae have been found which may have been killed by disease.

Climatic Control

In 1914, which was the driest summer experienced at Clarksville in 30 years, extensive digging in August disclosed the fact that a considerable number of the unparasitized larvae were dead and dried up in their thick silken cocoons, and larvae have been found much more susceptible to disiccation in the insectary than, for example, the larvae of *Feltia ducens*. The position of the cell within about one-fourth inch of the surface is advantageous to the emerging moth, but it must be the cause of a considerable mortality among the larvae.

THE C-NIGRUM GROUP

THE SPOTTED-SIDED CUTWORM, AGROTIS BADINODIS GRT.

Distribution

The reported range of this species includes the Atlantic coast from New York to North Carolina and extends westward to Iowa, Kansas, and Texas. The species is also credited to Canada. Larvae have been examined from Clarksville and Hixson, Tenn., South Boston, Va., and Galena, Kans.

Food Plants

The observed food plants include clover, *Rumex crispus*, *Sisymbrium officinale*, chickweed, *Aster ericoides*, and tobacco. The larva shows a decided preference for Rumex and chickweed and is sometimes rather common about these plants. Owing to the early completion of the active stage of their development, larvae have very rarely been found in tobacco fields and on but one occasion have they been taken injuring plants in a plant bed. This species is entirely negligible as a destroyer of tobacco.

Seasonal History

This is a single-brooded species. The winter is passed as larvae in the second and third instars. These begin to become mature the latter part of March and begin to enter the soil for pupation early in April. By the last of April practically all of the larvae are in the soil, the period of maximum entrance being from about April 7 to 21, although rare stragglers extend the period of larval activity to even as late as the end of the first week in June. After about two weeks in the soil the larvae pupate and the pupal stage extends over a period of over four months. Moths begin to emerge the very last of September, and the entire emergence is crowded into the period between this and about the third week of October, although moths continue regularly in flight until the last of October and stragglers may be taken as late as the middle of November.

Description of Stages

ADULT (PL. 3, K)

General color brown; hind wings somewhat infuscated; collar very dark brown; forewings with darker areas subapically and medially and a black spot at the lower inner margin of the orbicular spot. Expanse about 1½ inches.

EGG

The egg is white, circular in outline, strongly, bluntly subconical in profile, 0.62 and 0.63 mm. broad and 0.53 to 0.55 mm. high, with about 25 straight, thin, strongly elevated ribs and many slender transverse lines, and the micropyle is set in a depression. About the second day after deposition a very distinct belt and micropylar splotch of pinkish appear, and the egg becomes plumbeous some time before hatching.

LARVA

This larva may be distinguished by the presence of a subdorsal series of triangular black spots at least posteriorly and oblique black spots just above the spiracles. The mandible is also provided with a characteristic large, bidentate, internal tooth (fig. 6, F).

First instar.—Head 0.36 mm. broad. Body about 3 mm. long and 0.41 mm. broad; broadest through first four abdominal segments; skin closely set with rather coarse, acutely conical chitinous granules both dorsally and ventrally; greenish from the food. Cervical shield transverse, subtrapezoidal, emarginate posteriorly. Anal shield rhomboidal, deeply incised posteriorly. Head shield brownish fuscous. Setigerous tubercles dark fuscous, I to V of about equal size, IV and V slightly larger, their setae long, not at all capitate. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10, gradually longer posteriorly, their crochets united to the tips by a membrane.

Second instar.—Head 0.50 mm. broad. Body about 5 to 6 mm. long and 0.80 mm. broad at middle; enlarged gradually on the thorax, abdominal segments of about equal width throughout; skin very minutely, closely granulose above, less distinctly below; greenish from the food, tinged with ferruginous or fuscous, the white middorsal and subdorsal lines distinct, broken, the median demarcated broadly with fuscous which is constricted at the juncture of the segments, above the spiracles on the abdomen a segmental series of large, oblique, dark fuscous spots, venter pale with a white subspiracular band. Cervical shield transverse, trapezoidal, emarginate posteriorly, brown, the margins and bases of the setae dark fuscous. Anal shield paler, deeply incised posteriorly. Head shield ground color very pale grayish or white, front white, median arcs straight, dividing the head shield into three subequal parts, the brownish reticulation so arranged that the head shield appears reticulate with pale, ocelli and bases of setae dark. Setigerous tubercles dark, distinct even on the pale venter, I and II about equal in size, setae acutely pointed. Spiracles circular, black. Prolegs pale, the large shields dark fuscous, crochets united nearly to their tips in a membrane. Legs dark fuscous.

Third instar.—Head 0.70 mm. broad. Body about 7 mm. long and 0.86 mm. broad; of about equal width throughout; ground color pale yellowish with more or less pinkish dorsally, middorsal pale line broken, more distinct anteriorly and broadly demarked with fuscous, subdorsal line sulphur yellow, supraspiracular band fuscous, more intense below where a segmental series of oblique dark spots may be differentiated at least anteriorly, venter pale yellowish. Head shield ground color pale brownish, submedian fuscous arcs nearly straight dividing the head shield longitudinally into three subequal areas. Setigerous tubercles dark fuscous. Spiracles black. Prolegs functional on abdominal segments 3, 4, 5, 6, and 10, pale, the crochets united by a membrane, the large shields dark fuscous. Legs pale.

Fourth instar.—Head 1.1 mm. broad. Body about 8 mm. long and 1.2 mm. broad; of about equal width throughout; the eighth abdominal segment slightly enlarged; skin smooth; ground color pale yellowish with more or less pinkish dorsally, a series of linear fuscous marks on the abdomen just dorsal to the yellow subdorsal line, the dark supraspiracular spots distinctly differentiated anteriorly. Head shield ground color very pale grayish, the reticulation but slightly developed. Other characters as in third instar.

Fifth instar.—Head 1.5 mm. broad. Body about 21 mm. long and 3.5 mm. broad; coloration and other characters as in the mature larva.

Sixth instar.—Head 2 mm. broad. Body about 23 mm. long and 4 mm. broad; coloration and other characters as in the mature larva.

Seventh instar (pl. 9, D, E, H).—Head 2.5 to 2.7 mm. broad. Body about 25 to 32 mm. long and 5 mm. broad; of about equal width throughout but gradually enlarged posteriorly; skin smooth; ground color of body pale grayish to yellowish overlaid with fuscous flecks and sooty black spots, general effect of dorsum dark grayish, with sooty black triangular markings laterally on the abdominal segments margined by a subdorsal yellowish line, supraspiracular area concolorous with dorsum and bearing a similar series of sooty black spots above the spiracles having their upper margins somewhat oblique, below spiracles abruptly paler flecked obscurely with pale and fuscous. Cervical shield fuscous with a strong conspicuous pale median line and less distinct lateral line. Anal shield declivous, nearly concolorous with adjacent parts. Head shield shining, ground color pale yellowish brown with pale adfrontal sutures, the median arcs dark fuscous, heavy, somewhat angularly arcuate near the apex of front inclosing a large reticulated area above the front, subdorsal and ocellar lines fuscous, reticulation fuscous to ferruginous, the adfrontal sutures terminating distinctly before reaching the occipital foramen. Setigerous tubercles inconspicuous, of about equal size. Spiracles black. Legs and prolegs concolorous with venter, the anterior pair of prolegs each with about 18 to 31 crochets.

Mouth parts: Mandibles with a large, bidentate, internal tooth. (Fig. 6, F.) Hypopharynx suboval, broadest posteriorly, the lingua occupying about one-third the length of the part, and set with minute spinules which, back of the anterior margin, are appressed, retrorse, and placed in transverse rows, the premaxillulary area with close-set heavy spines, lobes of maxillulae clothed throughout with minute spinules, blade of maxillulae with about 7 to 10 strongly isolated, heavy, terete, spurlike teeth, gorge bare except anteriorly. Labial palpi in the proportion of 30, 4, and 5. Spinneret fimbriate apically. (Fig. 10, P.)

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. A^2 nearly or quite as near to A^1 as to P^a. A^a decidedly nearer to A^2 than to P^a. P^1 approximately equidistant from Adf^1 and Adf^2. P^1 on or somewhat below the level of Adf^2. Punctures F^a somewhat below the level of setae F^1. SO^a decidedly twice as near to SO^3 as to SO^2 but not approximately anterior to the seta. SO^3 decidedly nearer to O^3 than to G^1. G^1 distinctly nearer to O^3 than to SO^3. G^1 distinctly nearer to G^a than to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa (fig. 17, C) about 16 mm. long and 5.5 mm. broad, broadest about the apex of the wing covers, a row of large circular pits on anterior margin of movably linked abdominal segments, spiracles directed laterally, cremaster without spinules, spines short, outcurved, set on a long subconical process.

LIFE HISTORY

PREOVIPOSITION PERIOD

Moths which emerged on the night of October 2, 1914, deposited fertile eggs on the night of October 5, three days after emergence.

EGG STAGE

TABLE 38.—*Duration of egg stage in Agrotis badinodis*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Oct. 5, 1914	Oct. 22, 1914	17	64.3	Oct. 19, 1914	Nov. 10, 1914[1]	22	57.7
Oct. 7, 1914	Oct. 25, 1914	18	63.3	Oct. 17, 1916	Nov. 11, 1916	25	55.1
Oct. 9, 1914	Nov. 1, 1914[1]	23	58.8	Oct. 21, 1915	Nov. 11, 1915	21	60.5
Oct. 16, 1915	Nov. 2, 1915	17	61.6	Oct. 19, 1914	Nov. 12, 1914[1]	24	57.3
Oct. 11, 1914	Nov. 3, 1914	23	58.2	Oct. 17, 1916	Nov. 12, 1916	26	55.3
Oct. 10, 1916	Nov. 3, 1916	24	55.9	Oct. 21, 1914	Nov. 18, 1914[2]	28	53.9
Oct. 18, 1915	Nov. 5, 1915	18	59.8	Oct. 20, 1916	Nov. 18, 1916	29	53.0
Oct. 13, 1916	Nov. 5, 1916	23	56.0	Oct. 21, 1916	Nov. 20, 1916	30	52.9
Oct. 16, 1914	Nov. 8, 1914[1]	23	59.1	Oct. 25, 1916	Nov. 24, 1916	30	52.7
Oct. 15, 1916	Nov. 8, 1916	24	56.5	Oct. 23, 1914	Nov. 30, 1914[1]	38	50.1
Oct. 16, 1916	Nov. 9, 1916	24	55.6	Nov. 15, 1916	Dec. 24, 1916	39	40.7
Oct. 17, 1916	Nov. 10, 1916	24	55.2				

[1] 2 sets of eggs. [2] 3 sets of eggs.

LARVAL STAGE

Larvae which hatched November 11, 1915, were just entering the last instar on March 4, 1916, and nearly all the larvae in this species are mature by the middle of April. The active larval period, then, has a duration of about five months. The prepupal stage requires about two weeks.

PUPAL STAGE

Of 89 larvae which entered the soil between April 7 and May 4, 1914, 73 entered between April 13 and 23. Twenty-five moths emerged on dates between September 28 and October 15, 18 appearing between October 1 and 8. Allowing two weeks for the prepupal stage, the duration of the pupal stage is seen to be about five months. Of the above larvae, 68 entered a normal turf in an outdoor cage and 21 were reared in clay cells under moist conditions. In the outdoor cage 21.5 per cent of the larvae produced moths, and of the larvae in clay cells 62 per cent produced moths.

Parasites and Predators

In 1921, 32 larvae were collected when nearly mature and reared singly in tin boxes with unsterilized field earth. Mortality was as follows:

Moths emerged		4
Parasitized		20
Insects:		
Paniscus geminatus Say	9 larvae.	
Dipteron	4 larvae.	
Disease:		
Sorosporella uvella (Krass.) Gd	3 larvae.	
Beauveria sp	1 larva.	
Botrytis rileyi Farl	1 larva.	
Entomophthora sp	1 larva.	
Polyhedral disease (?)	1 larva.	
Died as larvae without apparent cause		6
Died as pupae without apparent cause		2

The brownish eggs of *Paniscus geminatus* are placed singly on the prothorax of the host larva and the parasite lies partly within the eggshell after hatching. Parasites hatching the first week in April produced adults about the middle of May. The dipteron listed above deposits chalk-white eggs about 0.88 mm. long and 0.32 mm. broad and flattish with a rounded-oblong outline. Several eggs are deposited on the thorax of each host larva.

THE SPOTTED CUTWORM, AGROTIS C-NIGRUM L.

Distribution

This species is found in the North throughout the east-and-west breadth of the United States and in Canada, but in the southern part of the United States it is scarce or absent. Alaska, Europe, and Asia are also included in the range of this insect. Larvae have been examined from the District of Columbia, Richmond, and South Boston, Va., Hixson and Clarksville, Tenn., and Holland, Mich. They are usually not common at Clarksville, and neither larvae nor moths have been received from farther south than Tennessee in the eastern half of the United States. The records available to the writer indicate that Virginia, Tennessee, Missouri, Kansas, and Arizona mark the approximate southern limit of the species.

Food Plants and Habits

This cutworm is a very general feeder, the plants attacked including apple leaves, beet, cabbage, Canada thistle, carrot, cauliflower, celery, chickory, chickweed, clover, corn, currant, ferns, gooseberry, grasses, Helianthus, Lobelia, maple leaves, mangel, oat, pea, pear, rhubarb, Solidago, tobacco, tomato, turnip, violet, and wheat.

This is considered to be one of our worst cutworms. The literature contains a few references to its having done injury by climbing trees and shrubs to feed upon the buds or foliage, and it has frequently been observed, when occurring in large numbers, to assume the army-worm habit, often in company with the army worm (*Cirphis unipuncta* Haw.). The most common injury due to this species is that done in gardens, for which it seems to have a special preference.

Seasonal History

Knowledge of the seasonal history of this species is unsatisfactory owing to lack of success in breeding the progeny of the moths emerging in the spring. There are apparently three broods in this latitude (Clarksville, Tenn.). The winter is passed as larvae, usually nearly mature in size. These are found in the last instar by the middle of February and begin to pupate the latter part of March, nearly all having entered the soil by about the middle of April. Moths begin to emerge the last of April and continue to emerge until the latter part of May. Eggs from these moths hatch in a few days and the larvae develop rapidly, but the writer has failed to obtain moths. Nine moths taken in bait traps July 27 to 29, 1915, evidently belong to this second brood. Third-brood moths begin to make their appearance early in September and continue on the wing until the latter part of October. Eggs deposited by these moths produce the overwintering larvae.

In Illinois, Forbes (*26*, *28*) found that larvae hibernated nearly full grown, pupating late in April and in May. Moths emerged the latter part of May and the first half of June. Second-brood larvae taken July 16 entered the soil for pupation July 25, and moths appeared August 15 to 19. Second-brood moths began to appear late in July, continued to emerge to the middle of August, and were found on the wing throughout September. This second brood was the last one. Gibson (*33*), in Canada, has found the seasonal history to be very much like that reported by Forbes, but states that moths of the second brood continue to emerge until the latter part of August and are on the wing as late as October 10.

Description of Stages

ADULT

Moth (pl. 3, J) fuscous tinged with brown or brownish; hind wings pale shaded with fuscous and with a brownish tinge; the collar mostly pale yellowish. A dark transverse dash on the costa of the forewing subapically; orbicular spot V-shaped, open anteriorly, pale brownish in color tinged slightly with reddish and contrasting strongly with the broad black area bordering it posteriorly and laterally. Expanse about 1½ to 1¾ inches.

EGG

The egg is white, circular in outline, broadly ovoid in profile, 0.60 to 0.65 mm. broad and 0.50 to 0.61 mm. high, with about 29 to 35 strong ribs and many faintly indicated transverse lines. Two days after deposition the eggs become entirely suffused with pinkish.

LARVA

This larva has a subdorsal series of segmentally arranged triangular black markings, at least posteriorly; the spiracles are yellowish or whitish with black rims; there is only the slightest trace of dark markings above the spiracles (pl. 8, G); the ground color of the head shield is grayish or whitish; and the internal tooth of the mandible is bluntly pointed at the apex. (Fig. 6, E.)

First instar.—Head 0.35 mm. broad. Body about 2 to 4 mm. long and 0.5 mm. broad; skin set ventrally and at the juncture of the segments with minute rounded granules; white; cervical shield trapezoidal, dark fuscous. Anal shield U-shaped open posteriorly, dark fuscous. Head shield dark fuscous. Setigerous tubercles dark fuscous, subconical, those on thoracic dorsum small and distinctly longitudinal, on the abdomen rounded and of about equal size, their setae long, very slightly capitate. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10, becoming gradually longer posteriorly.

Second instar.—Head 0.55 mm. broad. Body about 6.2 mm. long and 1 mm. broad at middle; gradually enlarging posteriorly; skin smooth; green from the food, with distinct, broken, middorsal and subdorsal white lines, a broad fuscous supraspiracular band including two distinct, irregular white lines, and a broad white band below the spiracles. Cervical and anal shields concolorous with adjacent parts. Head shield very pale grayish yellow or brownish, the submedian arcs scarcely represented, a dark reticulated area extending among and back of the dark ocelli. Setigerous tubercles not prominent, dark, of about equal size, their setae very slightly capitate.

Third instar.—Head 0.80 to 0.86 mm. broad. Body about 9 mm. long and 1.5 mm. broad; posteriorly from about the first abdominal segment of about equal width, the eighth abdominal segment slightly enlarged; skin smooth; general color olivaceous green, somewhat darker in the supraspiracular area, the dorsum speckled with white, with middorsal, subdorsal, and pair of supraspiracular broken lines white, a distinct white band below the spiracles, venter very pale greenish flecked with white. Cervical and anal shields concolorous with adjacent parts. Head shield ground color pale grayish with fuscous submedian arcs and reticulation. Setigerous tubercles of about equal size, brownish, ill-defined, those on the thorax not differing in shape from the abdominal tubercles. Spiracles dark and nearly circular, except on eighth abdominal segment. Legs very pale brownish. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10, growing gradually longer posteriorly.

Fourth instar.—Head 1.3 mm. broad. Body about 12 to 16 mm. long and 2 mm. broad; abdominal segments of equal width except the slightly enlarged segment 8; skin smooth; general color brownish or olivaceous brownish, darker in the supraspiracular area, the black subdorsal triangles indicated but not distinct even posteriorly, a pale band just below the spiracles margined with yellowish white above and more or less tinged with pink, venter pale flecked with white and fuscous. Head shield ground color pale gray, a fuscous reticulate area above the apex of the front, the lateral reticulation fusing to form an ocellar line. Legs and prolegs pale.

Fifth instar.—Head 1.7 mm. broad. Body about 14 to 20 mm. long and 2.5 mm. broad; abdomen of uniform width throughout; skin smooth; dorsum and sides drab or olivaceous greenish, darker in the supraspiracular area, the underlying pale yellowish being here overlaid closely with flecks of fuscous and sooty black, middorsal pale line broken, indistinct, black triangular subdorsal spots present posteriorly, pale lines in supraspiracular area scarcely indicated, venter of much the same color as the dorsum, a prominent pale band below, the spiracles margined with white above and tinged with ferruginous. Cervical and anal shields concolorous with adjacent parts. Head shield ground color pale yellowish or whitish, the median arcs and reticulation fuscous, a large reticulate area above the apex of the front. Setigerous tubercles small, inconspicuous, dark, and of about equal size. Spiracles yellowish with dark rims. Legs pale brownish.

Sixth instar.—Head 2.1 mm. broad. Body about 28 mm. long and 3.5 mm. broad; of about equal width throughout; skin smooth; a pale band below the spiracles usually fading out below and tinged with salmon pink, skin without a noticeable metallic sheen, coloration otherwise as in mature larva. Cervical and anal shields concolorous with adjacent parts. Legs pale brownish. Other characters as in the mature larva.

Seventh instar (pl. 9, A–C, G).—Head 3 mm. broad. Body about 30 to 36 mm. long and 6.5 mm. broad; of about equal width throughout, abruptly declivous after eighth abdominal segment; skin smooth; ground color pale yellowish gray more or less overlaid with flecks and spots of fuscous and sooty black, the general dorsal effect being usually a dark uniform drab with a dull metallic sheen and traces of a pale middorsal line; subdorsally a segmental series of sooty black, triangular spots obsolete anteriorly, more pronounced posteriorly; abruptly, nearly uniformly paler below the spiracles. Anal shield small, declivous. Cervical shield fuscous with traces of a pale median line. Head shield shining, ground color whitish, the fuscous or ferruginous reticulation fused to form a deep fuscous subdorsal line and a spot below the ocelli, submedian arcs broad, deep fuscous, rather angularly diverging at the apex of the front, inclosing a large reticulated area above the front, paraclypeal sutures pale, terminating distinctly before reaching the occipital foramen. Setigerous tubercles of about equal size, minute. Spiracles yellowish or whitish with black rims. Legs brownish fuscous. Anterior pair of prolegs each with about 25 crochets.

Mouth parts: Mandibles with a large, bluntly pointed internal tooth. (Fig. 6, E.) Hypopharynx elongate, scarcely oval, the lingua occupying about half the length of the part and clothed with slender, short, weak spines longer posteriorly, very heavy very short spines in the premaxillulary area, maxillulae entirely bare, the blades each with about ten terete, somewhat isolated teeth, gorge about as wide as the two maxillulae together, entirely bare, the gorge and maxillulae abruptly depressed at the posterior margin of the lingua. Spinneret broad and short, apically truncate, the apical margin produced to form slender spinules. (Fig. 10, O.) Labial palpi with the segments in the proportion of 30, 4.5, and 7, the papilla on the basal segment subapical.

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. P^1 equidistant from Adf^1 and Adf^2 or slightly nearer to Adf^1. P^1 on or slightly below the level of Adf^2. P^a, A^a, and A^2 not in a straight line but sometimes approaching this condition. Punctures F^a distinctly below the line of setae F^1. SO^a nearly anterior to SO^3 and three or more times as near to SO^3 as to SO^2. G^1 distinctly nearer to O^3 than to SO^3. G^a slightly nearer to O^3 than to G^1. G^1 distinctly nearer to G^a than to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa (fig. 17, A) about 18 mm. long and 6 mm. broad, maxillary palpi visible, labrum not emarginate, prespiracular callus absent on prothorax, movably linked abdominal segments with close, fine, round punctures on anterior third, spiracles broad, directed laterally, cremaster with four hooked spinules, spines rather long, slender, forming a narrowly lyre-shaped figure, set on a process, areas anterior to and below the spines smooth.

LIFE HISTORY

PREOVIPOSITION PERIOD

One moth emerged on the night of May 1, 1913, and two others appeared in the cage on the night of May 2. Eggs were obtained from these on the night of May 6, five or six days after emergence, but these eggs were infertile. It is of interest, as indicating possible unusual features in the breeding habits of this species, that the writer has never succeeded in obtaining fertile eggs from bred moths, although they have been kept under conditions which have yielded fertile eggs of most of the other species.

EGG STAGE

TABLE 39.—*Duration of the egg stage in Agrotis c-nigrum*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
Apr. 28, 1918	May 7, 1918	9	67.0	Sept. 30, 1915	Oct. 11, 1915	11	57.0
Apr. 30, 1918	May 9, 1918	9	66.6	Do	Oct. 12, 1915	12	57.3
May 3, 1918	do	6	71.4	Oct. 4, 1915	Oct. 16, 1915	12	56.6
Sept. 18, 1918	Sept. 29, 1918	11	59.9	Oct. 6, 1915	Oct. 17, 1915	11	58.8
Sept. 27, 1915	Oct. 5, 1915	8	66.9	Oct. 10, 1915	Oct. 18, 1915	8	65.1
Sept. 29, 1915	Oct. 11, 1915	12	57.5	Oct. 12, 1915	Oct. 20, 1915[1]	8	67.5

[1] 2 individuals.

LARVAL STAGE

Larvae which hatched October 20, 1915, pupated on April 4 to 12, indicating that the overwintering larval stage requires about five or six months. The larval stage in summer probably requires about a month or slightly more in each of the two broods. Gibson (*33*) states that larvae which hatched June 26 were beginning to enter the soil for pupation on July 25.

PUPAL STAGE

TABLE 40.—*Duration of pupal stage in Agrotis c-nigrum*

Pupated night of—	Emerged night of—	Pupal stage	Pupated night of—	Emerged night of—	Pupal stage
		Days			*Days*
Mar. 29, 1913	May 1, 1913	33	Apr. 12, 1916	May 11, 1916	29
Mar. 26, 1913	May 2, 1913	37	Apr. 4, 1918 [2]	May 11, 1918 [2]	37
Mar. 29, 1913	do	34	Apr. 4, 1916	May 12, 1916	38
Apr. 3, 1913	May 6, 1913	33	Apr. 7, 1916	May 13, 1916	36
Apr. 7, 1916	May 8, 1916	31	Apr. 23, 1915	May 14, 1915	21
Apr. 3, 1916	do	35	Apr. 4, 1916	May 15, 1916	41
Do.[1]	May 9, 1916 [1]	36	Apr. 23, 1918	May 18, 1818	25
Do	May 10, 1916	37	Apr. 29, 1918	May 20, 1918	21
Apr. 4, 1916 [2]	do.[2]	36	Apr. 30, 1918	May 21, 1918	21
Apr. 7, 1916	do	33	May 3, 1918	May 22, 1918	19
Apr. 9, 1916	do	31	Apr. 30, 1918	May 23, 1918	23
Apr. 15, 1913	May 10, 1913	25	Apr. 29, 1918	do	24
Apr. 4, 1916	May 11, 1916	37	May 7, 1918	May 24, 1918	17

[1] 4 individuals. [2] 2 individuals.

Eleven larvae shortened to pupate March 24, 1916. Five of these pupated on the night of April 3 and four pupated on the night of April 4, giving a prepupal stage of 10 or 11 days at this season.

PARASITES

Specimens of *Ophion bilineatum* Say, which had emerged from the larva and cocooned the previous season, emerged in March, 1919. The writer also obtained a species of Amblyteles from pupae May 17–19, 1918.

Chittenden (*10*) records (*Ichneumon*) *Amblyteles comes* (Cress.) from the pupa and an Apanteles species from larvae. Muesebeck (*48*) records *Apanteles xylinus* (Say) and *A. yakutatensis* Ashm. from this species. Franklin and Lacroix (*29*) record the following parasites: *Winthemia quadripustulata* Fab., *Phorocera claripennis* Macq., *Amblyteles seminiger* Cress., and *Euplectrus bicoltor* Swed.

THE W-MARKED CUTWORM, AGROTIS UNICOLOR WLK. (NOCTUA CLANDESTINA HARR.)

DISTRIBUTION

This is a northern species occurring throughout the east-and-west breadth of the United States and in Canada, the southern limit of its range being approximately Kentucky, Missouri, Kansas, Colorado, Utah, Nevada, and California. Larvae have been examined from Champaign, Ill., Ashby, Mass., and College Park and Rockville, Md.

FOOD PLANTS

The larva attacks a variety of plants, including apple, asparagus, bean, box elder, buckwheat, cabbage, cauliflower, celery, chickory, clover, corn, currant, gooseberry, grasses, lettuce, soft maple (*Acer saccharinum*), peach, plantain, pumpkin, tobacco, and wheat. The records indicate that this is preeminently a climbing cutworm, ascending apple, box elder, maple, and peach trees and other smaller shrubs to feed upon the buds.

Seasonal History

The data upon which the following tentative seasonal history of this species is based are taken from the writings of Forbes (*28*), Harris (*36*), Slingerland (*58*), Riley (*54*), and Gibson (*33*). There is doubt as to whether there are two broods or only one brood. Moths begin to emerge rather early in June and continue on the wing as late as the middle of October, the period of maximum abundance being apparently from about the middle of June to the middle of August or earlier. Moths are, therefore, abroad over a period of more than four months, although apparently in reduced numbers during the last two months of this period.

In northern Tennessee certain species are able, under the most favorable circumstances, to complete the cycle from moth to moth in a minimum of six weeks. Two months would probably represent the minimum average for the more northern latitudes from which the data are drawn. On the basis of two months from moth to moth the second brood of *unicolor* might begin to appear early in August and the flight of the entire brood might be over by the middle of October. But Gibson has observed that the egg stage requires more than two months in this species. An egg stage of much longer duration occurs in several of the species included here, and, if the above record represents approximately the normal duration of the egg stage in *unicolor*, the occurrence of a second brood is scarcely possible, since the second-brood moths could not begin to emerge until late in September and moths are not found later than the middle of October.

It seems probable that this is a one-brooded species having a period of retarded development following the emergence of the moths and that this period is chiefly occupied by the egg stage, but possibly to some extent by an unusually long preoviposition period. The winter is passed as small larvae which are said to go into hibernation at the approach of severely cold weather and to reappear about half grown in very early spring. Most of these larvae attain mature size in April and May, or in May and June in Canada, and the moths begin to appear rather early in June.

Description of Stages

ADULT (PL. 3, I)

Deep brown, collar unicolorous with thorax, outline of orbicular spot and inner margin of reniform spot black, which color may also connect the two spots and extend somewhat past the orbicular toward the base of the wing. In the female there is a peculiar structure on the venter of the penultimate abdominal segment on each side consisting of a deep smooth depression, the function of which is unknown. Hind wings whitish more or less infuscated. Expanse 1.6 to 1.7 inches.

The moths are said to conceal themselves in the daytime in crevices, and sometimes become troublesome by entering houses in large numbers. The eggs of this species are not known to the writer.

LARVA

The writer has examined only a few preserved larvae of this species, and these have shown some discrepancies in coloration, as is also the case with the published figures and descriptions. There is a series of segmentally arranged black subdorsal markings at least posteriorly, and these include setigerous tubercle I; the spiracles are yellowish or whitish with black rims; the spiracles are at least narrowly inclosed in dark spots; the ground color of the head shield is pale brown; and the internal tooth of the mandible has a broad apex. (Fig. 6, D.)

Mature larva (pl. 9, F, I).—Head 2.7 mm. broad. Body about 28 mm. long and 5 mm. broad; abdominal segments of about equal width throughout, the eighth segment slightly enlarged; skin smooth; general color gray to brown with a series of segmentally arranged, subdorsal, black markings on the abdomen which may unite middorsally to form W-shaped figures open anteriorly or may be oval or subtriangular in outline and are bordered externally by a broad, continuous yellow line; middorsal pale line rather broad and distinct, including the spiracles, a segmental series of isolated or narrowly connected black spots which may be inconspicuous, a pale band below the spiracles, venter pale. Cervical and anal shields concolorous with adjacent parts. Head shield ground color a decided brown with fuscous median arcs and reticulation, the reticulation fused to form a line each side of the ocelli. Setigerous tubercles and their setae minute. Spiracles pale yellowish or white, with black rims. Prolegs pale, the anterior pair each with about 33 crochets.

Mouth parts: Mandibles with five teeth on the cutting margin and a large, apically broad, internal tooth. (Fig. 6, D.) Hypopharynx oval, broadest posteriorly, the lingua occupying about half the length of the part and bearing only a few isolated rows of small spinules anteriorly, heavy spines in premaxillulary area, blade of maxillulate with about 12 coarse, bluntly pointed, isolated, terete spines, gorge bare, excepting a few spines anteriorly. Labial palpi with the segments in the proportion of 20, 4, and 5. Character of spinneret not determinable in the material at hand, but probably resembling that of *Agrotis c-nigrum*.

Relationships of head setae and punctures not determined.

PUPA

Pupa (fig. 17, B) about 16 mm. long and 5 mm. broad, maxillary palpi visible, labrum not emarginate, prespiracular callus absent on prothorax, movably linked abdominal segments with small round punctures anteriorly, spiracles narrow, directed laterally, cremaster with hooked accessory spinules, spines set close together, long, gradually attenuate, forming together a narrowly lyre-shaped figure, a small area anterior to the spines and a similar one beneath them regulose.

LIFE HISTORY

Gibson (*33*) states that eggs were deposited in patches on the side of the box in which the moth was confined and that eggs secured in August did not hatch until the end of October. Riley (*54*) observed that the larvae began to pupate the latter part of May and that moths began to appear shortly after the middle of June. Slingerland (*58*) found that larvae which were nearly full grown April 29 produced moths June 11 and 12. It is generally agreed that the winter is passed as hibernating larvae. According to these records the egg stage requires over two months at the season noted, and the pupal stage probably requires about a month or five weeks.

GENUS PRODENIA

GENERAL CHARACTER OF LARVAE

This is a sharply defined group of larvae characterized by the absence of teeth on the blade of the maxillulae, by the third segment of the labial palpi which is as long as the basal segment, by peculiarities in the arrangement of the head setae and punctures as indicated below, and by having the subdorsal black markings angular on their dorsal faces and, for this reason, broadest about midway of their length instead of posteriorly as is the case with the other species bearing similar subdorsal marks.

These larvae do not seem to bear a close relationship to any of the other species included here. They are evidently rather closely related to Laphygma. This relationship is considerably obscured in the mature larvae, although they are similar in several peculiar details, but the eggs and the manner of their deposition and the larvae in the first two instars are nearly or quite indistinguishable.

The larvae of the three species of Prodenia included here are scarcely distinguishable structurally. There are a few details in the arrangement of the head setae which show a tendency toward specificity, but these particular details are variable. Punctures F^a are slightly below the level of setae F^1 in *eridania* and on the level of these setae in the other two species. And these latter are readily separable from *eridania* by the coloration of the head shields and may be mutually distinguished by colorational characters as indicated in the descriptions of the species.

THE SEMITROPICAL ARMY WORM, PRODENIA ERIDANIA CRAM.

Distribution

This species is reported from Georgia, Florida, Texas, and California, and the author has taken what was evidently a sporadic colony of larvae at Clarksville, Tenn. It also occurs in Porto Rico, Central America, and South America. Larvae have been examined from Clarksville, Tenn., Dallas, Tex., Allapata and Coconut Grove, Fla., and Pernambuco, Brazil.

Food Plants and Habits

The larva has been observed to feed upon *Amaranthus spinosus*, avocado, beet, blood root, cabbage, carrot, castor bean, citrus trees, clover, collard, cotton, cowpea, crab grass, eggplant, okra, oleander, peanut, pepper, pokeweed, potato, Rumex, Solanum, sunflower, Sonchus, sweet potato, velvet bean, tobacco, tomato, watermelon, and willow. The larvae found at Clarksville, about 100 in number, were about the base of a large stump where they hid about tufts of crab grass and clover and beneath tobacco leaves and suckers on the ground.

Larvae are said to be gregarious when young, dispersing when approaching maturity unless they occur in great numbers, when they may travel in compact bodies after the manner of the army worm (*Cirphis unipuncta*). In an outbreak at Orlando, Fla., Chittenden and Russell (*15*) estimated that on 10 plants of *Amaranthus spinosus* 6 feet high there were 1,300 larvae. They fed freely in the daytime, not only stripping plants of their foliage but also consuming the tips of the branches, the pith in the stems, and even potato tubers in the soil. Berger (*4*) observed, in a general outbreak in Florida, in 1918, that, when attacking castor beans, the larvae, after consuming the leaves, ate the petioles and the tips of the branches. The larvae congregating about the base of the plants in the daytime were also observed to gnaw off the bark near the base. He states that in this outbreak 200 to 400 large larvae were not infrequently counted on a single castor-bean leaf in badly infested areas and in castor-bean fields and cotton fields pupae were found to occur to the number of 30 to 50 per square foot. Patches of careless weed (*Amaranthus spinosus*) and pokeweed (*Phytolacca decandra*) were found to be centers of infestation.

Seasonal History and Life History

The writer is unable to furnish any important data on the seasonal history or life history of this species. Mature larvae collected early in October produced moths about the middle of November at Clarksville and a large number of larvae in about the third instar were collected at Allapata, Fla., September 30, 1918, by Max Kisliuk.

Chittenden and Russell (*15*) found that there are at least four broods and possibly five in this species, larvae being present throughout the summer at Orlando, Fla. From a limited number of observations they found that the egg stage required from 4 to 6 days in July and August, the larval stage 17 days in July, and the pupal stage from 9 to 13 days in July and August. From eggs deposited July 3, moths were obtained August 5, giving the length of a generation as 33 days in extremely hot weather.

Description of Stages

ADULT

Coloration of the forewings varies from considerably darker than that shown in Plate 3, F, to a nearly immaculate pale brownish or yellowish. The hind wings are white with the margin and veins faintly infuscated. Expanse from 1¼ to 1½ inches.

EGG

The egg is greenish, circular in outline, 0.45 mm. broad and 0.35 mm. high, with about 50 ribs which are very slender and form with the transverse lines a rather uniform square-meshed reticulation. They are deposited in masses covered with scales from the body of the moth.

LARVA

The yellow ground color of the head shield in this species is overlaid with submedian arcs and close reticulation of bright brown which may be somewhat infuscated in an area beside the front, but this infuscation does not tend to cover the entire dorsal portion of the head shield as in the other two species. In this species also the adfrontal sutures are pale but never white as in the larvae of the other species. The subdorsal mesothoracic spots are as in *ornithogalli*. The general distinctive characters are discussed under the head of the genus.

Mature larva (pl. 8, G, L).—Head 2.6 to 2.7 mm. broad. Body about 38 mm. long and 5 mm. broad at middle; of practically uniform width throughout, the eighth abdominal segment very slightly enlarged; skin smooth; general color above a deep, uniform gray, sometimes tinged with olivaceous or pinkish, middorsal line, subdorsal stripe and subspiracular stripe unicolorous, whitish tinged with orange or pinkish, the subspiracular much the broader and including some of the spiracles; laterally on the dorsum a segmental series of black triangles which may appear on every segment but the prothorax or which may be almost entirely obsolete except posteriorly on the abdomen and which are broadest about midway of their length; lower half of supraspiracular area dark fuscous, upper half paler, venter suffused with pinkish or orange and much flecked with white. Head shield ground color pale yellow overlaid heavily with bright reddish brown reticulation which is more or less fused forming solid areas of reddish brown, without any trace of the solid black coloration found in the other two species except occasionally in a small area beside the base of the front; adfrontal sutures pale, adfrontal area brown. Setigerous tubercles minute. Spiracles brown with dark rims. Legs uniform infuscated brown. Prolegs pinkish, the anterior pair each with about 20 to 22 crochets.

Mouth parts: Mandibles with the upper tooth replaced by a broad, smooth, or crenulated margin. Hypopharynx much as in *Agrotis ypsilon*, the spines weaker and the blades of the maxillulae without teeth. Spinneret rather long, apically produced and minutely notched. Labial palpi with the segments in the proportion of 22, 5, and 23.

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. A^2 approximately equidistant from A^a and A^1 or with A^a somewhat the nearer. A^2 approximately twice as near to A^1 as to P^a. A^a distinctly nearer to A^2 than to A^3. A^a more than twice as near to A^2 as to P^a. A^3 the ocellar width from ocellus II. P^1 approximately equidistant from Adf^1 and Adf^2 or slightly nearer to Adf^2. P^1 on or slightly below the level of Adf^2. P^a, A^a, and A^2 approximately in a straight line. Interspace A^2 to A^a approximately half of P^1 to P^a. O^1 on or anterior to the line connecting ocelli IV and VI. Punctures F^a slightly below the level of setae F^1. Ocellus VI nearly or quite twice as near to O^1 as to O^3. Relation of L^1 to L^a and O^2 not determinable. SO^a nearly directly anterior to SO^3 and three times as near to SO^3 as to SO^2. SO^3 distinctly nearer to O^3 than to G^1. G^1 distinctly much nearer to O^3 than to SO^3. G^a variable in relation to G^1 and O^3 but nearer to G^1. G^1 at least three times as near to G^a as to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 17.5 mm. long and 5 mm. broad, prespiracular callus not present on prothorax, movably linked abdominal segments with anterior third set closely with fine round punctures, spiracles broad, directed strongly posteriorly, cremaster without spinules, spines slightly divergent, not quite meeting at the base with the juncture rounded.

PARASITES AND PREDATORS

Chittenden and Russell (*15*) record as parasites *Ophion* (*tityri* Pack.) *bilineatum* Say, and species of Limnerium, Meteorus, Chelous, and Spilochalcis, the last of which emerged from the cocoons of the Meteorus. They also state that upward of 50 per cent of the larvae taken at random were parasitized by tachinids, of which *Winthemia quadripustulata* Fab. was the only species reared. The predacious enemies included *Calosoma sayi* Dej., *Polistes annularis* L., and three bugs, *Stiretrus anchorago* Fab. var. *dina* Fab., *Podisus maculiventris* Say, and *Apateticus* (*Eupodisus*) *mucronatus* Uhl. The larvae of *Pontia rapae* were also observed to feed on the eggs of the Prodenia. A fungus, apparently a species of Empusa, killed a few larvae. Berger (*4*) records that J. E. Graf observed Calosoma (probably *C. sayi*) both in the adult and larval stages, several bugs, and the jackdaw, quail, meadow lark, ricebird, and shrike among the predatory enemies of this species, and that in some spots he found 75 per cent of the larvae parasitized by tachinids, but thought that it was on an average 50 per cent. Muesebeck (*48*) records *Apanteles grenadensis* Ashm. from this species, and (*50*) also lists this species among the hosts of *Meteorus autographae* Mues.

1431—29——10

THE LARGER COTTON CUTWORM, PRODENIA DOLICHOS FAB. (PRODENIA COMMELINAE S. & A.)

DISTRIBUTION

This species occurs along the Atlantic coast from Massachusetts to Florida and west to Illinois, Kansas, and Texas. A few larvae are taken every summer at Clarksville, but it is not a common species and seems to reach the maximum of abundance in the Gulf area. Larvae have been examined from Clarksville, Tenn., Quincy and Lake City, Fla., and British Honduras.

FOOD PLANTS

The list of food plants includes tobacco, Physalis, *Nicandra physalodes*, tomato, turnip, Jimson weed, asparagus, violet, *Commelina communis*, ground pea, sweet potato, cotton, raspberry, and grass.

Larvae have been found feeding on tobacco at Clarksville on several occasions and also at Quincy, Fla., and, like the larvae of *P. ornithogalli*, they often feed exposed upon plants in the daytime.

SEASONAL HISTORY

The writer knows nothing of the seasonal history of this species before the latter part of July. Eggs deposited July 21, 1917, produced a larva July 26, which pupated August 18, and the moth emerged September 6. Moths reared from larvae taken in the field have emerged from the last of August through September and up to the middle of October, and one reared moth emerged November 13, 1911. The writer has taken mature larvae in the field on various dates between August 13 and October 5, and fourth-instar larvae the fore part of September. The winter is probably spent in the pupal stage.

DESCRIPTION OF STAGES

ADULT

Forewings dark, with a ground color of gray having a pinkish suffusion, intricately marked with pale as shown in Plate 3, H. The hind wings white, iridescent, the margin narrowly infuscated. Moth characterized by the broad brown and black inner margins of the shoulder lappets, by the pale oblique dash on the disc of the forewing across the pale median vein and including the base of veins 3 and 4, and by the oblique pale area on the apical third of the wing. Further characters of this species are discussed under *P. ornithogalli*. Expanse from about 1½ to 2 inches.

EGG

The egg is greenish, circular in outline, biscuit-shaped in profile, 0.46 mm. broad and 0.36 mm. high, with about 50 slender but slightly elevated ribs and many transverse lines.

The eggs are deposited in masses of one or more layers, more or less completely covered with scales from the body of the moth, and containing several hundred eggs. The egg is scarcely distinguishable from that of *P. ornithogalli*.

LARVA

In this larva the head shield is brown, overlaid, and nearly entirely concealed dorsally, by black, and the adfrontal areas and sutures are conspicuous white as in *ornithogalli*. In *dolichos* the subdorsal spots on the mesothorax are distinctly larger than in *ornithogalli*, being nearly or quite as large as the corresponding spots on the eighth abdominal segment. The general distinctive features of Prodenia larvae are discussed under the head of the genus.

First instar—Head 0.27 mm. broad. Body about 3 mm. long and 0.69 mm. broad; tapering strongly both anteriorly and posteriorly from about the first abdominal segment; skin more sparsely granulose than in *ornithogalli;* general color green from food, with more or less vinous in the subdorsal region concentrated on first and seventh abdominal segments to form prominent spots. Cervical shield dark fuscous, trapezoidal. Anal shield U-shaped opening posteriorly, dark fuscous. Head shield dark fuscous. Setigerous tubercles distinct, dark fuscous, I and II of abdomen of about equal size, III, IV, and V larger and of about equal size, their setae long and scarcely capitate. Legs fuscous. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10. No characters have been found by which this species may be distinguished from first-instar *ornithogalli.*

Second instar.—Head 0.41 mm. broad. Body about 5.5 mm. long and 1.1 mm. broad at middle; distinctly broadest through metathorax and first two abdominal segments slightly enlarged; green from the food, with more or less vinous particularly above and below the spiracles, this coloring concentrated on first and seventh abdominal segments to form conspicuous spots, middorsal and subdorsal lines, traces of a pair of supraspiracular lines, and a band below the spiracles, white. Cervical shield inconspicuous brown, trapezoidal. Anal shield pale fuscous, roundingly rhomboidal. Head shield a distinct brown, flecked with fuscous. On abdominal segments setigerous tubercle I distinctly larger than II particularly anteriorly, tubercule III of first and seventh abdominal segments larger than I, elsewhere equal or smaller. Legs black. A very careful comparison of specimens of this species with those of *ornithogalli* hatched the same day has disclosed no character by which the two species may be distinguished in this instar.

Third instar.—Head 1 to 1.1 mm. broad. Body about 12 to 14 mm. long and 1.7 to 2 mm. broad at middle; distinctly broadest through the metathorax and first abdominal segment with abdominal segments 7 and 8 slightly enlarged. Head shield clear brown, unmarked. In shape and coloration this larva is a duplicate of the same instar in *ornithogalli,* except that, in *dolichos,* there is a transverse row of minute white dots on the dorsum of the metathorax which are absent in *ornithogalli,* the striping of *dolichos* is less distinct, and the dorsal fuscous color is broken up into smaller flecks than in *ornithogalli.* This last may be due to individual variation.

Fourth instar.—Head 1.5 to 1.6 mm. broad. Body about 17 to 23 mm. long and 3 to 4 mm. broad at middle; slightly enlarged on mesothorax, metathorax, and abdominal segments 7 and 8; skin smooth; general color a dark gray produced by a mixture of minute white and fuscous dots, suffused with pinkish, the curved subdorsal spots on mesothorax, a lateral pair of spots on first abdominal segment, a series of subdorsal triangular spots on abdominal segments at least posteriorly, jet black, on dorsum of metathorax and first abdominal segment a transverse row of four white dots, the black spots on mesothorax about as large as the corresponding spots on eighth abdominal segment, venter of dorsal coloration. Head shield brown, with fine fuscous reticulation. no solid black dorsally, the adfrontal sutures white. Setigerous tubercles minute. Spiracles brown with dark rims.

Fifth instar.—Head 2.2 to 2.5 mm. broad. Body about 30 mm. long and 5.2 mm. broad. Head shield usually with solid fuscous dorsally, the adfrontal sutures white, the adfrontal area brown. Coloration as in fourth instar except as above noted.

Sixth instar (pl. 8, E, F).—Head 3.1 to 3.3 mm. broad. Body about 35 to 43 mm. long and 6 to 8 mm. broad at the middle, and about as thick as broad; broadest through the metathorax and first, second, seventh, and eighth abdominal segments; skin smooth; ground color of entire body above the spiracles ocher yellow faintly tinged with glaucous and overlaid to a greater or lesser degree with fuscous flecks so that the general dorsal color may vary from very light to very dark gray, usually soft light gray, dorsal area including a median orange line and a segmental series of indistinct diamond-shaped fuscous markings connected at their lateral angles with a series of jet-black spots linear anteriorly, larger and triangular posteriorly, and broadest about midway of their length, the corresponding spots on the mesothorax arcuate within and nearly or quite as large as the corresponding spots on the eighth adbominal segment; subdorsally an orange band, yellow above, next the black spots, supraspiracular area of dorsal color, darker below, with a broken median yellow line, and forming a dark spot on first abdominal segment, below the spiracles a sinuate orange band with a similar band of white flecks below, more ventrally dull brownish closely flecked with clear white. Cervical shield with the minute dots, three lines, and the margin yellow; head shield brown, fuscous dorsally and with yellowish flecks posteriorly, adfrontal sutures yellowish white and terminating distinctly before reaching the occipital foramen. Legs brown, fuscous apically. Prolegs and shields brownish, the former tinged with pink, the anterior pair each with about 20 to 27 crochets.

Mouth parts: Mandibles with the upper tooth replaced by a broad crenulated margin. Hypopharynx much as in *Agrotis ypsilon*, the lingua occupying somewhat less than half the length, blades of the maxillulae without teeth. Spinneret rather long, apically produced and minutely notched. Labial palpi with the segments in the proportion of 28, 5, and 29.

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. A^2 approximately twice as near to A^1 as to P^a. A^2 approximately equidistant from A^a and A^1. A^a decidely nearer to A^2 than to A^3. A^3 somewhat more than the ocellar width removed from ocellus II. P^1 equidistant from Adf^1 and Adf^2 or nearer to Adf^2. P^1 slightly below the level of Adf^2. P^a, A^a, and A^2 approximately in a straight line. O^1 on or anterior to the line connecting ocelli IV and VI. Ocellus VI nearly twice as near to O^1 as to O^3. SO^a nearly anterior to SO^3 and three or more times nearer to SO^3 than to SO^2. SO^3 distinctly nearer to O^3 than to G^1. G^1 distinctly much nearer to O^3 than to SO^3. G^a variable but somewhat nearer to G^1 than to O^3. G^1 about three times as near to G^a as to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa about 23 mm. long and 7 mm. broad, prespiracular callus absent on prothorax, movably linked abdominal segments with fine round punctures on anterior third, spiracles broad, directed strongly posteriorly, cremaster without spinules, spines somewhat divergent.

LIFE HISTORY

EGG STAGE

TABLE 41.—*Duration of the egg stage in Prodenia dolichos*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
July 21, 1917	July 26, 1917	5	65.1	Sept. 6, 1917	Sept. 12, 1917	6	68.9
Aug. 31, 1917	Sept. 5, 1917	5	72.6	Sept. 7, 1917	Sept. 14, 1917	7	65.7
Sept. 3, 1917	Sept. 7, 1917	4	75.9	Sept. 9, 1917 [1]	Sept. 17, 1917 [1]	8	65.7

[1] 2 lots.

LARVAL STAGE

A larva which hatched July 26, 1917, pupated on the night of August 18, giving a larval stage of 23 days. Another larva was collected while still very small on June 23, 1913, and pupated July 21, indicating a larval stage of about 30 days. Larvae hatching September 7, 1917, were ready to molt into the last instar on September 27.

PUPAL STAGE

A few pupal stages have been recorded in July and August and these ranged in duration from 14 to 18 days. Smith and Abbot (*63*) record that a pupa formed August 19 produced the moth September 10.

PARASITES

The writer has reared *Winthemia quadripustulata* Fab. from larvae of this species on several occasions.

THE COTTON CUTWORM, PRODENIA ORNITHOGALLI GN.

Distribution

Moths have been taken from Massachusetts and New York westward to Minnesota, Nebraska, New Mexico, Arizona, and California, but the species is common only in the South. It also occurs in the Bahama Islands, Porto Rico, and Mexico. In northern Tennessee the larvae are always present in tobacco fields in summer and are occasionally rather common, particularly in the fall.

Larvae have been examined from Washington, D. C., North Carolina, Clarksville, Tenn., Fountain City, Okla., Valdosta, Ga., Holly Springs, Miss., College Station and Uvalde, Tex., Allapata, Fla., Bahama Islands, and Tlahualilo Durango, Mexico.

Food Plants

The known food plants include *Amaranthus retroflexus*, *A. spinosus*, asparagus, aster, bean, beet, cabbage, castor bean, clover, corn, cosmos, cotton, cottonwood, cucumber, *Erigeron canadensis*, grass, Jimson weed, moon vine, morning glory, *Necandra physalodes*, onion, pea, peach, petunia, *Plantago lanceolata*, pokeberry, potato, rape, raspberry, rhubarb, Rumex, rutabaga, salsify, *Sida spinosa*, *Solanum carolinense*, soy bean, sweet potato, tobacco, tomato, turnip, violet, watermelon, wheat, and wild onion.

Food Habits and Larval Habits

Larvae are unable to survive upon a diet of tobacco until they have reached the third instar, and until this stage is passed they skeletonize the leaves of clover and probably their other food plants, leaving the midribs and veins. These small larvae show a marked tendency to rest with the head and thorax turned to one side and slightly elevated.

All stages of larvae are not infrequently found feeding exposed in the daytime on tall weeds such as *Erigeron canadensis*, where they may be 5 or 6 feet from the ground, but in fields they are usually concealed beneath clods or débris on the ground or on the underside of leaves. On several occasions the writer has found larvae boring into tomatoes, and they are reported also as boring into cotton bolls. The species has been given the common name of the cotton cutworm owing to its destructiveness to young cotton plants and has been rerecorded as attacking various other field crops, including corn and wheat. The eggs are deposited in a mass, but the larvae usually occur but one or two in a place. This is due to the fact that the larvae upon hatching spin down from their support and are carried away by the wind, the rare cases of local abundance possibly being due to a period of calm at hatching time.

Seasonal History

There are four broods in this species. Moths of the first brood begin to emerge early in April and apparently sometimes much earlier, since a fourth-instar larva was collected in the field April 10, 1912. The emergence of this brood continues up to the last of May.

The second brood of moths begins to emerge the latter part of May and continues to emerge until the latter part of July. Third-brood moths begin to make their appearance early in July and continue to emerge through August. And fourth-brood moths emerge from the middle of August until as late as early November, and occasional moths are on the wing as late as the fore part of December. The progeny of the earlier members of this brood overwinter as pupae. An unusually large amount of seasonal-history data has been accumulated on this species from field observations, but this is not satisfactorily illuminated by continuous breeding records owing to the prevalence of a malady which almost invariably carries off all the larvae in breeding experiments. The line of data about which these minor details are grouped is given below.

Overwintering pupae have produced moths from early in April to about the middle of May. A third-instar larva taken May 8 produced a moth June 4 (second brood). From eggs deposited June 15 a moth was obtained July 31 (third brood). Eggs deposited August 19 produced a moth October 2 (fourth brood). Pupae formed from September 16 onward have hibernated.

This species passes the winter in the pupal stage only, in so far as the records indicate. The eggs are killed by a freezing temperature unless the larvae are ready to emerge. Larvae have been collected in the field as late as the middle of December, but all have been killed by the cold in the winter breeding experiments, and collecting in the spring in various situations, including those in which larvae were rather common late in the season, has never yielded any larvae. Attempts to hibernate late-emerging adults have failed, and field observations give no indication of the possibility of adult hibernation.

Description of Stages

ADULT (PL. 3, G)

Forewings dark, intricately marked with pale and more or less suffused with brownish, with an oblique pale dash on the disk of the wing across the pale median vein and including the bases of veins 3 and 4, and with an oblique pale area on apical third of the wing. Hind wings white, the margins narrowly infuscated. This moth resembles *P. dolichos* but differs in lacking the brown and black margins to the shoulder lappets, and the pinkish suffusion, and in being smaller. In *ornithogalli* there is also a distinct brown area encroaching in an acute angle upon the upper outer margin of the reniform spot and margined within with pale and with an indistinct pale transverse line below it. In *dolichos* this area is indefinite and narrowly fusiform and the transverse pale line below it is represented by a conspicuous oblique fusiform white spot. Expanse from about 1¼ to 1½ inches.

EGG

The egg is greenish, circular in outline, broadly oval in profile, 0.46 to 0.52 mm. broad and 0.38 to 0.40 mm. high, with about 45 to 58 slender ribs and many transverse lines, both of which are absent on the lower third. The second day after deposition the entire egg becomes suffused with iridescent pale pinkish or brownish.

The eggs are deposited on foliage, walls of buildings, twigs of trees, and other elevated objects in masses consisting of one or more layers, usually two, covered and intermingled with the grayish scales of the moth. Bred moths have oviposited freely without ever having taken food, and this species is very prolific. One egg mass contained 950 eggs and another about 500 eggs, and several similar masses are sometimes deposited by one moth in a single night.

LARVA

In addition to the distinctive characters of the genus, this larva has the brown ground color of the head shield nearly or quite concealed by black; the adfrontal areas and sutures are a conspicuous white; and the subdorsal black spots on the mesothorax are absent or decidedly smaller than the similar spots on the eighth abdominal segment. This last is the main distinctive feature between this species and *dolichos*. In *dolichos* the subdorsal spots on the mesothorax are decidedly larger than are ever found in *ornithogalli*, being nearly or quite equal in size to the spots found subdorsally on the eighth abdominal segment.

First instar.—Head 0.28 to 0.31 mm. broad. Body about 1.7 to 3.5 mm. long; broadest through the thorax and tapering posteriorly to the blunt posterior extremity; skin densely granulose ventrally, sparsely dorsally; whitish, or greenish from food, traces of a middorsal and two pairs of subdorsal white lines, below the subdorsal white lines a faint band of brownish or vinous spots. Anal shield small, dark fuscous, U-shaped, open posteriorly, the emargination extending about three-fourths the length of the shield and made cruciate by a pair of median lateral arms. Cervical shield small, dark fuscous, strongly narrowed posteriorly. Head shield black. Setigerous tubercles conspicuous, dark fuscous, III, IV, and V elongate-oval, I and II of abdomen of equal size, III and IV larger and of about equal size, V equaling IV in size or slightly larger, their setae long, fuscous, scarcely enlarged apically, tubercle II distinctly larger than I on the thorax. Functional prolegs on abdominal segments 3, 4, 5, 6, and 10, their shields crescent-shaped and black. Legs black.

Second instar.—Head 0.45 mm. broad. Body about 4 to 7 mm. long and 0.7 mm. broad; slightly broadest through abdominal segments 1 to 2 and slightly enlarged on segment 8; skin minutely granulose; general color pale brownish or yellowish, appearing deep green from the food, overlaid more or less with vinous especially posteriorly, with middorsal and subdorsal lines and the line above tubercle III white, distinct, vinous spots on first and seventh abdominal segments laterally, trace of a pale band below the spiracles. Head shield brownish, darker dorsally, adfrontal sutures concolorous with remainder of head. Setigerous tubercles prominent, dark fuscous, their setae slightly capitate, tubercle I of abdomen distinctly larger than II; III and V larger than IV. Legs and shields of prolegs dark fuscous.

Third instar.—Head 0.8 to 1 mm. broad. Body about 7 to 13 mm. long and 2 mm. broad at middle; broadest through metathorax and first abdominal segment, seventh and eighth abdominal segments slightly enlarged; general color of dorsum slaty or olivaceous gray, sometimes becoming maroon posteriorly, dorsal area with longitudinal strands of whitish, the median pale line set in maroon especially posteriorly, and margined laterally by a grayish or fuscous stripe of segmental series of spots bordered on their dorsal margins by a pale line and forming a velvety black spot on the mesothorax, subdorsally a clear yellow stripe more or less tinged with a pinkish, upper half of supraspiracular area pale, margined below with white, lower half, including the spiracles in its lower margin, of dorsal color, with a median pale line and forming a large velvety black spot on the first abdominal segment, below the spiracles two yellowish lines demarking a band of pinkish. Head shield varying in color from clear brown to a decided black, the adfrontal sutures pale to white. Cervical and anal shields brownish, shining. Setigerous tubercles minute. Legs and prolegs brown.

Fourth instar.—Head 1.4 to 1.6 mm. broad. Body about 10 to 18 mm. long and 3 mm. broad through the metathorax; at rest thickened on metathorax and first, seventh, and eighth abdominal segments; velvety maroon overlaid above with black or dull plumbeous, middorsal pale line broken, not prominent, margined with deep maroon, dorsal area bearing pale strands and flecks and flanked by a dark band of sooty black on the anterior half of each segment, margined above by a broken whitish line, and forming a prominent velvety black spot on the mesothorax; subdorsally a prominent, continuous, clear-yellow band, sometimes abruptly narrowed on the cervical shield, upper half of supraspiracular area maroon, with an included white line and another on the lower margin, lower half of supraspiracular area, including the spiracles in its lower margin, of dorsal color, including a pale median line and large velvety black spot on the first abdominal segment, below the spiracles a vinous band flecked with pale and margined above by a yellow line, below pale maroon, flecked with pale. Cervical and anal shields not distinctive. Head shield ground color clear brown, heavily infuscated dorsally, and adfrontal sutures pale. Spiracles minute. Legs brown.

Fifth instar.—Head 2 to 2.2 mm. broad. Body about 12 to 25 mm. long and 4.5 mm. broad; enlarged on the metathorax, on abdominal segments 1 and 2, and slightly on abdominal segments 7 and 8; skin smooth; dorsal area may vary in color from brownish fuscous to slaty gray and may be tinged more or less with maroon or olivaceous, the pale broken middorsal line margined with deep maroon, dorsal area margined, beginning on the mesothorax, by a series of velvety black spots separated on posterior margin of each segment by expansions of the dorsal color and margined above by a broken yellowish line, subdorsally a yellow band which may be whitish at the middle of each segment and marked with ferruginous, upper half of supraspiracular area composed of mixed strands of fuscous, ferruginous and whitish, or slaty gray and yellowish, margined both above and below with fuscous brownish, the lower half of the supraspiracular area, including the spiracles in the lower margin, of the dorsal color, flecked with pale and including a large velvety black spot on the first abdominal segment, below the spiracles a band of yellowish flecks margined above with orange. Head shield ground color brown, overlaid dorsally with solid deep fuscous, the adfrontal areas white. Setigerous tubercles minute. Legs fuscous brown. Prolegs yellow, shields brown to dark fuscous.

Sixth instar (pl. 8, D, K).—Head 2.8 to 3 mm. broad. Body about 20 to 36 mm. long and 6 mm. broad at the middle; enlarged on the metathorax, on abdominal segments 1 and 2, and slightly on abdominal segments 7 and 8; varying in general color from pale gray to jet black. In well-colored individuals the dorsal coloration is made up of intermingled strands of pale and fuscous, the subdorsal triangular black markings, which are broadest about midway of their length, may be conspicuous on all the abdominal segments or may be obsolete on all but the eighth, there may be a bright yellow band outside the subdorsal black triangles or this may be wholly absent, there is usually a distinct dark band including the spiracles in its lower margin and a subspiracular band of white flecks which may be more or less suffused with orange or pinkish. Head shield ground color brown overlaid and all but concealed dorsally by deep fuscous, adfrontal sutures and areas conspicuous white, the sutures terminating distinctly before reaching the occipital foramen. Setigerous tubercles minute. Spiracles brownish with dark rims. Legs brown. Prolegs yellowish, shields pale fuscous to black, the anterior pair each with about 17 to 25 crochets.

Mouth parts: Mandibles with the upper tooth replaced by a broad crenulated margin. Hypopharynx much as in *Agrotis ypsilon*, blades of the maxillulae without teeth. Spinneret rather long, the anterior margin produced, with an apical notch. Labial palpi with the segments in the proportion of 23, 4, and 25.

Setae and punctures of head: A^2 distinctly nearer to A^1 than to A^3. A^2 about equidistant from A^1 and A^a or with A^a somewhat the nearer. A^2 about twice as near to A^1 as to P^a. A^a decidedly nearer to A^2 than to A^3. A^a nearly twice nearer to A^2 than to P^a. A^3 about the ocellar width from ocellus II. P^1 approximately equidistant from Adf^1 and Adf^2. P^a, A^a, and A^2 nearly in a straight line. O^1 on or anterior to the line connecting ocelli IV and VI. Adf^2 above apex of front in most individuals. SO^a nearly directly anterior to SO^3 and three times as near to SO^3 as to SO^2. SO^3 distinctly nearer to O^3 than to G^1. G^1 distinctly much nearer to O^3 than to SO^3. G^a approximately twice as near to G^1 as to SO^3. Arrangement of setae and punctures otherwise as in *Feltia annexa*.

PUPA

Pupa (fig. 19, D) about 18 mm. long and 5.5 mm. broad, maxillary palpi not visible, labrum not emarginate, prespiracular callus absent on prothorax, punctures on movably linked abdominal segments small, round, spiracles broad, directed strongly posteriorly, cremaster without spinules, spines somewhat divergent, a very small area both anterior to and beneath the spines punctured.

LIFE HISTORY

TABLE 42.—*Length of generations in Prodenia ornithogalli*

Eggs deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Larva pupated night of—	Larval stage	Average mean temperature	Moth emerged night of—	Pupal stage	Average mean temperature	Life cycle	Average mean temperature
		Days	° *F.*		*Days*	° *F.*		*Days*	° *F.*	*Days*	° *F.*
July 21, 1917	July 24, 1917	3	77.3	Aug. 12, 1917	19	77.2	Aug. 28, 1917	16	72.4	38	75.2
July 23, 1917	July 26, 1917	3	77.8	Aug. 14, 1917	19	76.5	do	14	72.5	36	75.1
July 21, 1917	July 24, 1917	3	77.3	Aug. 13, 1917[1]	20	77.0	Aug. 29, 1917	16	72.2	39	75.1
July 23, 1917	July 26, 1917	3	77.8	Aug. 15, 1917	20	76.5	do	14	72.1	37	74.9
July 21, 1917	July 24, 1917	3	77.3	do.[1]	22	76.6	Aug. 31, 1917	16	71.7	41	74.7
July 23, 1917	July 26, 1917	3	77.8	do	20	76.5	Sept. 2, 1917	18	72.1	41	74.7
Aug. 11, 1917	Aug. 15, 1917	4	72.0	Sept. 3, 1917	19	71.8	Sept. 22, 1917	19	69.7	42	70.9
Do	do	4	72.0	Sept. 4, 1917	20	71.8	Sept. 23, 1917	19	69.3	43	70.7
Aug. 14, 1917	Aug. 17, 1917	3	75.2	Sept. 5, 1917[1]	19	71.6	Sept. 25, 1917	20	68.9	42	70.6

[1] 2 individuals.

PREOVIPOSITION PERIOD

One moth emerged on the night of June 11, 1912. Three others emerged on the following night. Fertile eggs were deposited on the night of June 15, 2 to 4 days after emergence. A pair emerged on the night of August 28, 1917, and were placed in a cage without food. Two large masses of fertile eggs were deposited on the night of August 31, 3 days after emergence. Seven moths emerged singly in tumblers on the night of October 7, 1913, and were caged together October 8. Fertile eggs were deposited October 9, 2 days after emergence.

EGG STAGE

TABLE 43.—*Duration of egg stage in Prodenia ornithogalli*

Deposited night of—	Hatched night of—	Egg stage	Average mean temperature	Deposited night of—	Hatched night of—	Egg stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
June 16, 1912	June 20, 1912	4	72.0	Aug. 17, 1916	Aug. 21, 1916[2]	4	82.1
June 15, 1912	June 22, 1912	7	73.4	Aug. 19, 1916	Aug. 23, 1916[1]	4	78.8
June 17, 1912	June 23, 1912	6	71.1	Aug. 20, 1916	Aug. 24, 1916[1]	4	75.5
July 4, 1914	July 7, 1914	3	80.1	Aug. 26, 1916	Aug. 31, 1916	5	68.7
July 6, 1914	July 9, 1914	3	84.1	Aug. 27, 1915	Sept. 2, 1915	6	68.4
July 21, 1917	July 24, 1917	3	77.3	Aug. 28, 1917	Sept. 3, 1917[1]	6	70.8
July 23, 1917	July 26, 1917	3	77.8	Sept. 1, 1917	Sept. 4, 1917	3	71.2
July 26, 1913	July 29, 1913	3	85.6	Sept. 2, 1917	Sept. 7, 1917	5	73.9
July 27, 1913	July 30, 1913	3	86.8	Sept. 5, 1917	Sept. 10, 1917	5	74.9
Aug. 6, 1914	Aug. 9, 1914	3	79.0	Sept. 11, 1916	Sept. 15, 1916	4	69.7
Aug. 11, 1917	Aug. 15, 1917	4	72.0	Oct. 5, 1914	Oct. 8, 1914	3	73.3
Aug. 12, 1916	Aug. 16, 1916	4	79.2	Oct. 9, 1913	Oct. 16, 1913[1]	7	65.3
Aug. 14, 1916	Aug. 17, 1916[1]	3	81.6	Oct. 11, 1913	Oct. 23, 1913[1]	12	56.4
Aug. 14, 1917	Aug. 17, 1917	3	75.1	Oct. 17, 1915	Oct. 27, 1915	10	62.0
Aug. 14, 1916	Aug. 18, 1916	4	82.0	Oct. 28, 1915	Nov. 7, 1915	10	59.4
Aug. 16, 1916	Aug. 19, 1916	3	83.0	Oct. 31, 1915	Nov. 9, 1915	9	60.4

[1] 2 sets of eggs. [2] 4 sets of eggs.

LARVAL STAGE

In addition to the larval stages shown in Table 42, those given in Table 44 have been recorded.

TABLE 44.—*Duration of larval stage in Prodenia ornithogalli*

Eggs hatched night of—	Larvae pupated night of—	Number of larvae	Larval stage	Average mean temperature	Eggs hatched night of—	Larvae pupated night of—	Number of larvae	Larval stage	Average mean temperature
			Days	° *F.*				*Days*	° *F.*
Aug. 22, 1908	Sept. 5, 1908	24	14	77.0	Aug. 22, 1908	Sept. 10, 1908	1	19	76.8
Do	Sept. 6, 1908	13	15	77.1	Do	Sept. 11, 1908	1	20	76.9
Do	Sept. 7, 1908	2	16	77.1	Aug. 24, 1908	Sept. 7, 1908	10	14	76.8
Do	Sept. 8, 1908	4	17	76.9	Do	Sept. 10, 1908	1	17	76.6
Do	Sept. 9, 1908	3	18	76.8					

The length of the first three instars is about two days each and the last three instars require about three days each.

PUPAL STAGE

TABLE 45.—*Duration of pupal stage in Prodenia ornithogalli*

Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature	Pupated night of—	Emerged night of—	Pupal stage	Average mean temperature
		Days	° *F.*			*Days*	° *F.*
May 23, 1914	June 4, 1914	12	79.3	Aug. 15, 1910	Aug. 30, 1910	15	75.7
May 20, 1911	June 8, 1911	19	72.3	Sept. 3, 1913	Sept. 13, 1913	10	79.1
July 7, 1915	July 17, 1915	10	83.0	Sept. 10, 1913	Oct. 3, 1913	23	68.6
July 22, 1916[1]	Aug. 2, 1916	11.5	73.8	Sept. 11, 1913	Oct. 7, 1913[3]	26	68.5
July 28, 1916	Aug. 7, 1916	10	81.4	Sept. 13, 1913	do	24	68.2
Aug. 1, 1916	Aug. 10, 1916	9	79.8	Do	Oct. 8, 1913[2]	25	68.4
July 27, 1910	Aug. 10, 1910	14	75.6	Sept. 14, 1913	Oct. 9, 1913[2]	25	69.0
Aug. 2, 1916	Aug. 11, 1916	9	80.4	Sept. 15, 1913	do.[4]	24	69.0
July 31, 1911	Aug. 11, 1911	11	80.5	Sept. 13, 1913	Oct. 10, 1913	27	69.1
Aug. 1, 1916	Aug. 12, 1916	11	80.2	Sept. 15, 1913	do	25	68.8
July 31, 1916	do	12	80.2	Sept. 16, 1913	do	24	69.2
Aug. 2, 1916	do.[2]	10	80.4	Sept. 17, 1913	Oct. 13, 1913[2]	26	68.3
Aug. 3, 1916	Aug. 13, 1916	10	80.2	Sept. 18, 1913	do.[2]	25	68.2
Aug. 4, 1916	Aug. 14, 1916[2]	10	79.7	Sept. 17, 1913	Oct. 14, 1913	27	68.2
Aug. 5, 1916	do	9	79.7	Sept. 18, 1913	Oct. 16, 1913	28	67.7
Aug. 7, 1916	Aug. 17, 1916	10	79.5	Sept. 19, 1913	Oct. 24, 1913	35	64.1
Aug. 10, 1916	Aug. 21, 1916	11	81.0	Sept. 17, 1913	Oct. 31, 1913	44	61.8
Aug. 14, 1910	Aug. 28, 1910	14	75.5	Sept. 23, 1913	Nov. 4, 1913	42	60.1

[1] Noon. [2] 2 individuals. [3] 5 individuals. [4] 3 individuals.

In addition to the pupal stages given in Table 45, the combined pupal and prepupal stages given in Table 46 have been recorded by C. R. Jones. Fifty larvae entered the soil on September 4, 1908, and 25 on September 6, giving an average date of entrance of September 5.

TABLE 46.—*Duration of period in soil of Prodenia ornithogalli*

Date moths emerged—	Number of moths	Average period in soil	Date moths emerged—	Number of moths	Average period in soil
		Days			*Days*
Sept. 21, 1908	2	16	Sept. 25–28, 1908	17	20–23
Sept. 22, 1908	10	17	Sept. 29–Oct. 1, 1908	6	24–26
Sept. 23, 1908	18	18	Oct. 2, 1908	1	27
Sept. 24, 1908	18	19			

PARASITES AND PREDATORS

In 1921 113 larvae were collected when nearly mature and reared singly in tin boxes with unsterilized field soil. Mortality was as follows:

Moths emerged		55
Parasitized		13
Insects:		
Ophion sp	3	
Winthemia 4-pustulata Fab	2	
Disease:		
Septicemia (?)	6	
Beauveria sp	2	
Died as larvae without apparent cause		41
Died as pupae without apparent cause		4

The adult of *Euplectrus platyhypenae* How. is about 1.5 mm. long, exclusive of the antennae; the body is black except a pale-brown triangular area on the dorsum of the abdomen anteriorly; and the legs and basal joints of the antennae are honey yellow, the remainder of the antennae being infuscated. The egg is black, 0.21 mm. long and 0.12 mm. broad, irregularly elliptical in outline, slightly arcuate in profile, and is attached to the skin of the host apparently by one end. The greenish larvae occur in a group to the number of about 10 to 25, and in hatching they split the eggshell and then lie within it, extruding only the head. The shell thus aids in retaining the parasitic larvae on the host. Third-instar larvae seem to be the ones most often oviposited upon.

A Euplectrus which had emerged July 31, 1912, was offered a larva of *ornithogalli* on the forenoon of August 2. The parasite immediately mounted the second abdominal segment of the larva, where it remained motionless for about a minute, except for the tapping of the antennae on the host; it then began ovipositing, and in two or three minutes had deposited four eggs slightly isolated on the second abdominal segment. The host seemed to be greatly irritated and, after four eggs had been deposited, succeeded in knocking the parasite off. While ovipositing the Euplectrus remained stolidly on the spot it had chosen even after the larva had fallen 8 or 10 inches and the parasite had been spit upon and brushed about by the angry host. The eggs, so far as observed, are deposited near the head, this being the part which the larva can defend least easily. The rate of oviposition shown by the above individual is exceeded by others, since the writer has observed a parasite which deposited 10 eggs in not more than 30 seconds.

The length of the various stages in *Euplectrus platyhypenae* How. is indicated in the following record of the transformations of two sets:

First set.—Eggs deposited August 10, 1912, a. m.; hatched about August 12; larva spinning August 16, a. m.; larvae pupated August 16; adults emerged August 21, 5 p. m.

Second set.—Eggs deposited August 2, 1912, 10 a. m.; hatched August 4, p. m.; larvae spinning August 11, 9 a. m.; pupated August 12; adults emerged August 17.

Upon reaching maturity the larvae with one accord leave the host and spin a meshwork of threads beneath its shrunken body in which they pupate. This parasite has oviposited on larvae which already bore eggs of a tachinid and also in a larva which contained a hymenopterous parasite which emerged before the Euplectrus larvae completed their growth.

The writer has also bred *Winthemia quadripustulata* Fab., *Enicospilus purgatus* Say, *Ophion bilineatum* Say, *Sagaritis provancheri* (D. T.), *Zele melleus* Cress., and a species of Apanteles from larvae. The Apanteles emerged from a third-instar larva and attached its cocoon to a leaf beside the body of the host. A coccinellid larva was observed to attack and kill a larva in the fifth instar, and a fifth-instar larva had been killed beside an injured tobacco plant by a diminutive spider, determined by Shoemaker as *Xysticus ferox* Hentz, which still held the larva in its grasp.

Chittenden (*10*) records a Limnerium species and *Litomastix* (*Copidosoma*) *truncatella* Dalm. from larvae. A. B. Gahan (*31*) describes *Hyposoter interjectus* from this species.

REMEDIAL CONTROL OF CUTWORMS

POISONS APPLIED TO PLANTS

DIPPING PLANTS IN SUSPENSIONS OF POISON BEFORE SETTING

A poison may be applied more cheaply and expeditiously by dipping the plants before setting than by spraying or otherwise distributing the poison in the field. But a rather large quantity of plant tissue must be consumed by a larva, when the poison is applied in this manner at a dosage which is safe for the plant, before the larva will cease feeding, and during this period, or because of attacks by several larvae, the plant may be ruined. A certain percentage of plants will also die from being wet and drabbled with earth, in case other conditions prove unfavorable.

Dipping plants in suspensions of poisons is not to be recommended as a remedy against cutworms, but is of some benefit in cases of mild infestation and at the same time assists in the control of flea beetles and grasshoppers. The following dosages, when the chemicals used are of high grade, may be safely used for dipping the tops, never the roots, of most tobacco plants. F. S. Chamberlin, however, has found that considerably greater dilutions are necessary for plants of the types grown in Florida.

Zinc ortho-arsenite, 1 pound to 24 gallons of water.
Lead arsenate, 1 pound to 16 gallons water.
Paris green, 1 pound to 48 gallons water.
Calcium arsenate, 1 pound to 32 gallons water.

DRY APPLICATIONS TO PLANTS IN THE FIELD

In some tobacco-growing sections it is the custom to dust the plants, after setting, with wheat flour, sifted wood ashes, corn meal, or rice flour, mixed with Paris green, in case cutworms begin to cause damage. This mixture is applied by means of a tin can which has a finely perforated bottom and is attached to a handle 2 or 3 feet long by which the can may be shaken close above each plant as the operator moves down the row.

Proportions of from 25 to 60 or more pounds of the diluent to 1 pound of Paris green are used in these mixtures, the concentration which may be safely employed depending upon the thickness of the coating which is applied to the plants and also upon climatic conditions. Four quarts of flour is sufficient to make a proper application on about 4,000 plants. These mixtures may be responsible for the loss of comparatively few plants when carefully applied, but in the effort to cover the entire plant there is a tendency to make the application too heavy over part of the surface, and injury is most serious when the bud is thus involved. A mixture of 40 pounds of flour and 1 pound of Paris green, applied heavily enough that the plants showed white across the field, caused the death of about one-third of the plants treated in the plat mentioned below, although the application was made by an experienced grower.

All of the above-mentioned diluents have been used with success, but it would seem that the ground cereals, being themselves palatable to cutworms, would attract the larvae to feed to some extent even when the mixture was on the soil, whereas the mixture including wood ashes would become effective only when the plants treated were eaten. Flour is objectionable as a carrier in that it tends to produce an injurious sticky coating on the leaves although it is somewhat commonly used for this purpose.

The writer has made a comparison, under rather unfavorable conditions, of the results obtained with a dry mixture and with a sweetened bran bait in adjacent plats in which cutworms occurred at the rate of 1,000 or more larvae per acre. The formulas and rates of application are given below.

Dry application.—Wheat flour, 40 pounds; Paris green, 1 pound. Rate of application about 6 quarts (dry) per acre.

Sweetened-bran bait.—Wheat bran, 25 pounds; Paris green, 1 pound; sirup, 2 quarts; water, 5 gallons. Rate of application 10 pounds per acre.

Both applications were made on the day the plants were set in the plats, but the bran bait was spread one day later than the flour mixture and was leached and mixed with earth by a fall of 0.66 inch of rain beginning about 7 p. m. of the night following the application, giving the flour mixture a decided advantage. In the dry application an examination two days after treatment showed 33 per cent of the plants fed upon and a mortality of 78.2 per cent, and after a similar period had elapsed the bran bait showed 44 per cent of the plants fed upon and a mortality of 75.8 per cent. The live larvae collected in these examinations were nearly all fed afterwards on unpoisoned food under excellent conditions and deaths occurring among these brought the mortality for the flour mixture to a total of 86.2 per cent eight days after the application and the mortality in the bran bait to 85.7 per cent seven days after the application.

The flour mixture was applied so thickly that one-third of the plants were killed by the treatment, and the bran bait was handicapped as stated above and it was further rendered unattractive by a too concentrated dosage of the poison, as discussed under "Dosage." These abnormalities, all favoring the flour mixture, render comparisons of uncertain value, but the results indicate that the bran bait, when properly made up, should kill better than a safe dosage of the dry application. Where flour is used as a diluent the materials in the two applications cost about the same, whereas dry applications where any of the other diluents are used are less expensive than bran bait if sirup is included in the bran bait. The labor cost is greater where the dry application is employed, since the bran bait can be dropped down two rows almost as fast as the dry material can be shaken on the plants in one row, and with less irksome labor. One great advantage which the bran bait has over the dry applications as now prepared lies in the entire safety which attends its use. The bran bait does not come in contact with the plants, while with the other method the poison is applied directly upon the plants under conditions which render the rate of application a matter of more or less accurate guesswork and where a too liberal coating may result in the loss of many plants. Also a dosage of the dry mixture which has proved safe in previous years may become very unsafe in another season, owing to conditions, such as moist weather followed by hot sunshine, which may intensify the caustic action of the poison. This source of loss might be eliminated by the use of a milder arsenical, such as zinc arsenite, but even in this case the use of a bran bait is preferable.

POISONED BAITS

Cutworms have a remarkable fondness for wheat bran; so great is this attractiveness that the larvae feed readily upon the moistened poisoned bran, even when it is giving off strong fumes of hydrocyanic-acid gas or when the bran has been just soaked in a 1 per cent solution of formaldehyde. Unless this attractiveness is reduced by the admixture of excessive quantities of other substances, cutworms find the bran more attractive than green vegetation, as indicated in Table 50. Poisoned baits owe their efficiency to this strong preference. Strickland (*68*) states, however, that bran has little attraction for the army cutworm (*Chorizagrotis auxiliaris*) under the prairie conditions prevailing in southern Alberta, particularly when the soil is dry, and has found shorts to be very much more satisfactory under these conditions. Alfalfa meal has also been used as a substitute for bran in making up poisoned baits. Berger (*4*) reports good results against *Prodenia eridania* with a bait consisting of half rice bran and half cottonseed meal, and poisoned vegetation may sometimes be used to advantage.

DILUENTS

J. J. Davis and W. H. Larrimer in 1917 sought to determine the feasibility of replacing bran with sawdust in order to reduce the cost of the bait. In these experiments, which were conducted in a field infested by the army worm (*Cirphis unipuncta*), they used dosages of 1 pound of Paris green to 25 pounds of sawdust and 1 pound of Paris green to 50 pounds of sawdust, checked by the same dosages of poisoned bran. Davis (*22, p. 6*) states:

> Examinations made two days after application showed approximately 75 per cent value in sawdust areas, and practically all were dead in the bran areas.

And Morrill (*46, p. 14*) states:

> A half-and-half mixture of pine sawdust and wheat bran frequently gives as good results as straight bran, and our observations show that a third sawdust at least can be safely recommended.

The writer has carried out a series of laboratory experiments with three species of cutworms under the standard conditions prescribed under the head of "Method of determining relative toxicity of poisons," except as noted below, in which different kinds and percentages of sawdust from seasoned timber have been tested, with the results indicated in Table 47:

TABLE 47.—*Results obtained with various proportions and kinds of sawdust in bran baits containing 1 part of Paris green to 96 parts of carrier*

Kind of sawdust	Per centage of sawdust	Results on fifth day		Percentage of larvae killed	Kind of sawdust	Per centage of sawdust	Results on fifth day		Percentage of larvae killed
		Larvae dead	Larvae alive				Larvae dead	Larvae alive	
Poplar	100	5	15	25.0	Pine	50	18	35	34.0
Oak	100	4	16	20.0	Poplar	25	25	13	65.8
Pine	100	2	17	10.5	Oak	25	26	13	66.7
Poplar	50	23	36	39.0	Pine	25	25	15	62.5
Oak	50	21	36	36.8		None.	67	16	80.7

An abundance of succulent vegetation, including white clover, chickweed, and tobacco suckers, was provided in all of the pans in an effort to make the results an index to the relative attractiveness of the baits as compared with green food. By this arrangement laboratory conditions were made to approximate the conditions under which the baits must function in the field. Care was taken that the baits did not become mixed with the vegetation, although the heap of green food lapped over the heap of bait and the heap of earth which were provided.

The tabulated results indicate that sawdust is slightly attractive to cutworms, the pine somewhat less so than the poplar or oak sawdust, but it is evident that the addition of even 25 per cent of this diluent reduces the attractiveness of the bait decidedly, and the addition of 50 per cent of sawdust decreases the attractiveness of the bait by about an equal amount. In a series of experiments involving 600 cutworms, in which fine and coarse sawdust were tested with bran at dilutions of one-fourth and one-half sawdust, the fine material was no more effective as a diluent than that produced by a coarse circular saw.

All of the above experiments owed their inception to the stress of war conditions. Under ordinary circumstances it would seem to be poor economy to cheapen the bait by replacing a portion of the bran with a substance which distinctly reduces the attractiveness of the remainder when the cost of the bran constitutes only about 25 per cent of the total outgo for materials and application.

BAIT POISONS

The choice of poisons for use in baits is limited chiefly by the insecticidal value of the compound in question and the degree of safety to the laborer which attends the application of the bait containing it. Some compounds have their value impaired by the repellent action they have upon cutworms; others, such as the compounds of sodium and potassium, are so highly soluble that they are readily leached from the bait and are also caustic; and other poisons containing copper have a slight advantage in that they inhibit the development of mold in baits in which they are included. Toxicity and causticity are both usually associated with solubility, the arsenites being nearly always more soluble, effective, and caustic than the corresponding arsenates; and, if the bait is not applied by mechanical means and in dry weather, this association of qualities must eliminate some otherwise satisfactory compounds.

The writer has tested 26 nonarsenical and 22 arsenical compounds with regard to their value as bait poisons, and has found that, with the exception of sodium flouride, all of the substances possessing suitable qualities are arsenicals.

METHOD OF DETERMINING RELATIVE TOXICITY OF POISONS

In each of the toxicity experiments recorded in the following pages, three features have been incorporated as safeguards:

(1) Uniformity in the preparation and exposure of the experimental materials has been maintained. In preparing for an experiment, two clean graniteware pans about 10 inches in diameter were provided for each poison to be tested. In one of these pans 24 grams of wheat bran was thoroughly mixed dry with the quantity of poison necessary to give the dosage desired; then 1 ounce of water (containing the sirup in case this was used) was added and the bait again thoroughly mixed; after which it was divided between the two pans, being placed in a compact heap on one side of each pan. On the opposite side of each pan was placed a similar heap of loose, slightly moist field earth, which provided for the larvae a lurking place essential in testing the toxicity of caustic and asphyxiating substances and added to the normality of the experiments by largely eliminating day feeding on the baits. In each of these pans were placed at 5 p. m. five larvae (later 10) carefully distributed according to species and size, some species, such as *L. saucia*, *A. ypsilon*, and *P. ornithogalli* being decidedly more susceptible to poisons than others and the smaller larvae often being more resistant than the larger ones. These pans were then placed in a row in an open insectary with the bait in one pan turned toward the source of light and the other away from it. Examinations were made on the morning of each following day until the experiments were arbitrarily terminated on the fourth day. After the second day a few drops of water were added to each bait if necessary.

(2) Each poison has been tested simultaneously at several dosages so distributed as to approach the limit of effectiveness of the compound. When the results obtained with a single dosage are used as a basis of comparison in arriving at the comparative toxicity of each of a series of poisons, the inferiority of those poisons whose limit of efficiency is below the dosage chosen will be indicated, but the true status of those poisons whose limit of efficiency is much above this dosage may not be revealed. Thus, if the standard dosage be set at 1 pound of poison to 24 pounds of bran, there is nothing in the experiments with this dosage, as indicated in the following tables, to show that Paris green, calcium arsenate, arsenic bisulphide, powdered arsenious oxide, and sodium fluoride would be equally effective at half the above dosage of poison, although such is the case. Also, in

the 1-dosage method of determining toxicity, there is no means of determining whether or not a compound is repellent at too concentrated dosages. To eliminate these sources of uncertainty the writer introduced the multiple-dosage tests.

(3) A standard check has been included in each experiment. Certain more or less uncontrollable factors, such as temperature, amount of sunlight, relative humidity, and condition of the insects may wield an influence sufficient to alter the results obtained in experiments conducted within a few days of one another. The effect of such factors is exemplified in Table 48, which gives the results of two series of experiments with Paris green.

TABLE 48.—*Difference in results in toxicity experiments against tobacco cutworms when the bait was exposed on different dates, indicating the influence of extraneous factors.*

Date experiment was begun	Dosage of poison to bran	First day		Second day		Third day		Fourth day	
		Dead	Alive	Dead	Alive	Dead	Alive	Dead	Alive
Apr. 19, 1917	1 to 96	0	10	3	7	9	1	10	0
Do	1 to 48	4	6	6	4	9	1	9	1
Do	1 to 24	6	4	9	1	10	0		
Apr. 21, 1917	1 to 96	5	5	10	0				
Do	1 to 48	8	2	10	0				
Do	1 to 24	8	2	10	0				

Although the same species of cutworm was used throughout the above experiments, the poison was all taken from the same package, and the materials weighed and mixed by the same person, an investigator might have felt justified in assigning a distinctly higher toxic value to the poison used in the second series, in case two compounds were being compared, than would have been given the equally toxic but less favored poison used in the first series.

On account of influences of this type the results of experiments conducted on different days may not be compared with entire safety; for this reason the writer has sought to make each experiment self-contained by basing conclusions as to the value of the poison tested on a comparison with the results obtained in the simultaneously exposed check.

EFFICIENCY OF ARSENICALS

In making the tests reported in Table 49, Paris green at a dosage of 1 pound to 96 pounds of bran was used as the check poison. At this dilution the Paris green is near the limit of its effectiveness, which is beyond the range of most other poisons, thus peculiarly adapting this dosage to purposes of comparison.

The numerical values assigned to the various poisons in Table 49 represent the opinion of the writer, based on the accompanying data relative to the percentage of larvae killed at various dosages as compared with the results obtained with the simultaneously exposed 1-to-96 dosage of Paris green. In general, fewer experiments have been made testing the more concentrated dosages, the 1 to 24 in particular, than have been devoted to establishing the status of the poisons at the 1-to-72 and 1-to-96 dosages, and consequently the results at the greater dilutions are more reliable. The tests at the greater dilutions are also more suggestive of the actual capabilities of poisons, such as arsenic bisulphide, arsenic trisulphide, calcium arsenite, potassium arsenate, and magnesium arsenate, in all of which a repellent action reduces the percentage of mortality at a certain concentration, the percentage killed often being higher both above and below this point. In most of the poisons enumerated above, the 1-to-72 dosage occupies this unfavorable position, the increased attractiveness of the bait at the 1-to-96 dosage offsetting the greater dilution of the poison, while the greater killing power at the 1-to-48 dosage is not accompanied by a corresponding increase in repulsion, making the poison more effective at this dosage.

TABLE 49.—*Relative efficiency of various arsenicals as cutworm-bait poisons*

Poisons	Percentage of mortality on fourth day						Value assigned	Number of larvae used
	Check test, Paris green at dosage of 1 to 96	Experimental tests of arsenicals at dosage of—						
		1 to 24	1 to 48	1 to 72	1 to 96	1 to 120		
Paris green	--------	100.0	100.0	97.5	89.5	95.0	100	825
Potassium arsenite	82.8	--------	100.0	85.3	84.4	--------	100	380
Ammonium arsenate	91.4	--------	96.6	--------	86.9	--------	95	167
London purple	100.0	--------	95.0	--------	100.0	--------	95	90
Copper arsenate	88.6	--------	80.0	91.6	81.6	--------	90	234
Strontium arsenite	86.6	--------	94.0	82.8	76.6	--------	90	288
Arsenic bisulphide	[1] 89.2	100.0	91.7	73.3	72.9	90.0	90	633
Arsenic trisulphide	[1] 85.0	--------	82.5	74.6	77.3	85.0	90	503
Sodium arsenite	100.0	--------	100.0	--------	90.0	--------	90	90
Zinc ortho-arsenite	88.3	100.0	100.0	78.8	74.3	--------	90	470
Magnesium arsenate	89.4	97.7	87.5	76.6	77.5	--------	85	225
Arsenious oxide	91.6	93.3	91.6	85.2	72.2	--------	75	537
Antimony arsenate	100.0	--------	100.0	87.5	73.7	--------	70	143
Calcium arsenite	[1] 91.9	80.0	68.0	79.2	71.1	33.3	70	338
Ferric arsenate	100.0	[2] 100.0	90.0	95.3	65.0	--------	65	123
Zinc arsenate	93.1	--------	80.0	82.7	62.0	--------	65	208
Ferric arsenite (basic)	100.0	100.0	90.0	83.3	66.6	--------	65	124
Calcium arsenate	86.6	80.0	91.5	52.5	30.9	--------	55	405
Potassium arsenate	[1] 87.5	--------	40.0	75.0	70.0	65.0	55	280
Mercuric arsenate	85.0	--------	55.4	--------	42.8	--------	30	135
Antimony arsenite	92.5	80.0	60.0	--------	36.0	--------	25	100
Lead arsenate (acid)	87.0	[2] 60.0	16.9	10.0	--------	--------	10	409

[1] In a test at a dosage of 1 to 120 the mortality was 95 per cent.   [2] 1 to 12 dosage.

Of the arsenicals listed in Table 49, the seven most desirable for use in cutworm baits are Paris green, copper arsenate, zinc ortho-arsenite, strontium arsenite, arsenic bisulphide, and magnesium arsenate. Of the remaining compounds having a toxicity equal to the above, potassium arsenite, sodium arsenite, and ammonium arsenate are very readily soluble in water and attack the hands; London purple is very variable in composition; and arsenic trisulphide is caustic as well as repellent. Any of the remaining compounds showing a value of 65 or more would probably give satisfactory results at a dosage of 1 to 24. It scarcely need be said that the mechanical condition of the compound used has a very important bearing upon its effectiveness as a bait poison, in case the compound is insoluble in water; thus a granular arsenious oxide at the 1 to 48 dosage killed only 43.4 per cent of the larvae in four days, while the powdered compound at the same dosage killed 91.6 per cent of the larvae in an equal time.

The calcium arsenate used in these experiments was the tricalcium compound, which is insoluble in water. The dicalcium arsenate, which is soluble in water, would probably have been much more effective. The lead arsenate used was the diplumbic or acid arsenate. In London purple the active ingredients are chiefly calcium arsenite and calcium arsenate, but the mixture appeared to be much more toxic in these experiments than either of the component arsenicals when tested alone.

NONARSENICAL COMPOUNDS

Owing to the ease with which the amino derivatives of benzene enter into combination with other substances, it was hoped that insecticidal action might be brought about by the combination of these substances with the tissues of larvae. Sulphanilic acid, aniline, aniline hydrochloride, and benzidine have been tested. Aniline hydrochloride, with a rank of about 10, is the only one of the above compounds showing a value above 1 in the scale. Aniline killed larvae readily by asphyxiation in closed vessels but had no insecticidal action in the open. A few other benzene derivatives have been tested, including phenol, phenol-sulphonic acid (ortho), nitrobenzene, and monochlor benzene. Phenol-sulphonic acid and nitrobenzene showed slight insecticidal properties; the other compounds none. The nitrobenzene killed larvae readily by contact or, in closed vessels, by asphyxiation.

The miscellaneous substances tested include alizarine, barium carbonate, barium chloride, barium sulphide, boric acid, calcium chloride, calcium sulphate, copper cyanide, derris, ferrous sulphate, formaldehyde, hydrazine sulphate, lead chromate, oxalic acid, phosphoric acid (ortho), potassium bichromate, potassium cyanide, and sodium fluoride. Potassium cyanide with a value of 15, copper cyanide with a value of 10, and sodium fluoride with a value of 90 are the only compounds of the above list having a value over 1 in the scale of assigned values. The rank assigned to sodium fluoride is based on experiments utilizing 320 larvae, in which the mortality at different dosages was as follows: 1 to 24, 90 per cent; 1 to 48, 96.2 per cent; Paris green 90 per cent at a dosage of 1 to 96. Sodium fluoride is only sparingly soluble in water and probably is not injuriously caustic.

DOSAGE

RELATION OF DOSAGE TO INFESTATION

When cutworms occur in vast numbers and any nice discrimination with regard to food which they may have possessed has been obliterated by the urge of hunger, a concentrated dosage of poison applied in a moderate quantity of bait is probably more economical than a prodigal application of bait at a lighter dosage. For this reason a dosage of 2 pounds of a good arsenical to 50 pounds of bran may be advisable in cases of gross infestation. The writer's field data on bait poisons other than Paris green are not sufficient to warrant positive conclusions regarding the maximum dilution of each poison which will still be effective under field conditions, but the evidence indicates that any of the seven most satisfactory arsenicals will give excellent results, in all but very extraordinary infestations, at a dosage of 1 pound to 50 pounds of bran at a rate of application of from 10 to 20 pounds (dry weight) per acre.

Dosage Tests with Paris Green

The writer has conducted a series of laboratory experiments comparing the efficiency of the 1 to 24 and 1 to 48 dosages of Paris green under the conditions described above under section (1) of "Method of determining relative toxicity of poisons," with the added conditions that in one section of each experiment a compact heap of fresh vegetation was added each evening to the materials in the pans and a large number of pans was used with 10 larvae in each. No sweetening was used. The results obtained are given in Table 50.

Table 50.—*Comparative efficiency of 1 to 24 and 1 to 48 dosages of Paris green*

Kind of green food	Number of larvae dead					Number alive	Date experiment was begun (1917) [1]
	First day	Second day	Third day	Fourth day	Fifth day		
DOSAGE OF POISON TO BRAN 1 TO 48							
Stellaria media	65	135	142	147	147	3	Sept. 24
None	28	50	55	57	58	2	Do.
Alfalfa	49	114	130	137	138	2	Sept. 26
None	19	56	59	60		0	Do.
Clover	30	113	130	134	138	2	Sept. 28
None	19	56	58	60	61	0	Do.
Total with food, per cent	33.5	84.2	93.5	97.2	98.4	1.6	
Total without food, per cent	36.5	89.5	95	97.8	98.9	1.1	
DOSAGE OF POISON TO BRAN 1 TO 24							
Clover	29	114	132	133	136	3	Sept. 25
None	28	59	60			0	Do.
Clover	32	102	129	134	136	4	Sept. 27
None	28	57	60			0	Do
Total with food, per cent	21.9	77.4	93.5	95.7	97.5	2.5	
Total without food, per cent	46.6	96.6	100			0	

[1] Each experiment was begun at 5 p. m.

In an examination of the data presented in Table 50 it should be borne in mind that the results obtained in the presence of green food represent an approximation of what may be expected under field conditions, and any discrepancy between these results and those obtained with the corresponding dosage without food is to be taken as a measure of the attractiveness of the green food over the bait as constituted.

On the above basis and examining the totals, it will be noted that the results in the "with food" and "without food" series are nearly parallel throughout with the 1 to 48 dosage. This indicates that at this dosage the bait was at least nearly as attractive as the green food with which it was intimately associated. An examination of the results with the 1 to 24 dosage, on the other hand, shows a wide discrepancy between the results in the two series, particularly for the first two days, indicating that the larvae preferred to feed upon the vegetation rather than on the bait at this concentration of poison. The dosage of 1 pound of Paris green to 24 pounds of bran is rather repellent to cutworms, while the bait with half this concentration of poison is scarcely at all repellent.

A comparison of the "with-food" series in the two dosages, constituting as it does a fair approximation of the efficiency of the baits under field conditions, shows that the 1 to 48 dosage is the more effective for the first two days and equal to the 1 to 24 dosage in the final result. This view of the status of these two dosages is supported by a large number of additional laboratory experiments and also by some field observations.

F. S. Chamberlin applied baits of the above formulas in a heavily infested tobacco field in Florida and two days later found 50 per cent of the larvae killed in the plat treated with the 1 to 24 dosage and 60 per cent killed in the plat treated with the 1 to 48 dosage. And in a tobacco field free from cutworms a small area beside each plant was loosened with the hoe to serve as a lurking place, the soil having been generally compacted by recent rains, and a larva of *Euxoa messoria* was dropped beside each of 46 plants in each of two rows several rows apart. The 1 to 24 dosage was applied to one of these rows and the 1 to 48 dosage to the other, at the rate of 15 pounds per acre. Four days later 17 plants were injured in the row treated with the 1 to 24 bait and 5 plants in the other.

BAIT FLAVORINGS

The attractiveness of a number of substances to cutworms has been tested by the writer in an apparatus made of galvanized iron and consisting of a round central chamber 6 inches in diameter and 3 inches high connected radially by narrow passages with each of six other chambers 8 by 4 by 3 inches, all equally accessible and exactly alike. The outer chambers were provided with tight covers fitted with ventilators which could be opened or closed to any desired degree, and the central chamber was provided with a tall ventilator tube which caused a current of air to flow through the outer chambers into the central one, into which the larvae were entered at the beginning of each experiment. Thirty-six grams of bran moistened with 1.5 ounces of water was placed in shallow pasteboard trays in each of the radial chambers, the flavoring to be tested being mixed with the bait in alternate compartments, the remaining three compartments containing moistened bran alone to serve as checks. The apparatus was frequently scrubbed and aired and the trays replaced, and this was always done when a new flavoring was to be tested. The position of the compartments with regard to the source of light was altered after each experiment, although the apparatus was run with the ventilators nearly shut and these were the only source of light in the outer chambers. The apparatus was set up for some time before larvae were entered, so that the odors might have time to reach the central chamber before the cutworms were admitted. The larvae were usually given 24 hours in which to satisfy any preference they might have for the odors, and their response was usually quite consistent throughout a series of experiments with any particular compound. Larvae were rarely used a second time, since they showed a strong tendency to become indifferent to odors when used repeatedly.

The results obtained with the apparatus just described are given in Table 51.

TABLE 51.—*Attractiveness of various substances to cutworms*

Flavoring in bran	Flavoring to 1.5 ounces of water	Number of larvae attracted to— Flavored bran	Number of larvae attracted to— Unflavored bran	Number of experiments	Remarks
Corn sirup	3.5 drams	641	402	7	Attractive only when fermented.
Lemon juice	(1)	340	351	9	Not attractive.
Lemon peel	(1)	336	351	9	Do.
Oil of orange peel (sweet)	4 to 8 drops	442	684	5	Repellent.
Citral	(1)	216	209	4	Not attractive.
Amyl butyrate	2 to 6 drops of 10 per cent solution.	501	472	9	Scarcely attractive.
Amyl nitrate	4 to 8 drops of 4 per cent solution.	344	349	6	Not attractive.
Ethyl acetate	4 to 8 drops	737	479	9	Distinctly attractive.
Ethyl aceto-acetate	do	549	312	7	Do.
Ethyl butyrate	2 to 6 drops	663	523	8	Somewhat attractive.
Oil of sweet birch	4 to 8 drops	628	688	6	Not attractive.
Vinegar	(1)	304	218	7	Somewhat attractive.
Salt	(2)	298	425	3	(2).
Nitrobenzene	3 to 6 drops	520	334	8	Distinctly attractive.
Citric acid	5 to 20 drops saturated solution.	976	932	9	Scarcely attractive.

[1] A sufficient quantity used to give the bait a distinct characteristic odor.
[2] The salt was tested in dosages in proportion to bran of 1 to 8, 1 to 16, and 1 to 20. The larvae were repelled by the higher concentrations of salt and were indifferent to the 1 to 20 dosage.

When first exposed the bait containing corn sirup was very slightly more attractive than the plain bran; but, on the second day and thereafter, when the bait became fragrant from the fermentation of the sirup, the larvae responded strongly to the sweetened bait. The oil of orange used was that expressed from the fresh peel, the characteristic aroma being chiefly due to the presence of citral. Amyl butyrate in 10 per cent solution has almost exactly the odor of banana, and amyl nitrate in dilute solution has a somewhat similar odor. Ethyl acetate and ethyl aceto-acetate are highly volatile minor constituents of vinegar and have a sharp vinegarlike odor. Ethyl butyrate in alcoholic solution forms the pineapple essence of commerce. Oil of sweet birch consists essentially of methyl salicylate, the flavoring principle in wintergreen. Nitrobenzene is the commercial oil of mirbane and is manufactured on a large scale for the preparation of aniline. It has a strong and highly tenacious odor resembling that of peach kernels, which is attractive to many insects.

SWEETENING IN POISONED BAITS

LABORATORY EXPERIMENTS

In a series of laboratory experiments to compare the efficiency of sweetened and unsweetened baits the writer has sought to combine in a measure the control of conditions and accuracy of records obtainable in the laboratory with the freedom of choice of food under which the bait must operate in the field. These experiments were carried out under the standard conditions enumerated above under section (1) of "Method of determining relative toxicity of poisons," with the added condition that a compact heap of green food overlapping the bait and the heap of earth was included in each of a number of pans and renewed daily. The proportions used in the unsweetened bait were wheat bran, 48 pounds; Paris green, 1 pound; and water, 9 gallons; and the sweetened bait differed only in that 3 quarts of sirup were added. The results obtained are given in Table 52.

TABLE 52.—*Comparative efficiency of sweetened and unsweetened baits poisoned with a 1 to 48 dosage of Paris green*

Green food	Sirup to water	Number of larvae dead					Larvae alive	Larvae missing	Total number of larvae	Date experiment was begun (1917)[1]
		First day	Second day	Third day	Fourth day	Fifth day				
Clover	1-12	9	53	69	73	77	3	0	80	Sept. 29
Do	None.	15	61	67	73	77	2	1	80	Do.
Alfalfa	1-12	17	40	60	68	74	2	4	80	Oct. 1
Do	None.	19	51	61	68	74	5	1	80	Do.
Tobacco	1-12	34	64	78	86	89	9	2	100	Oct. 2
Do	None.	27	70	81	87	89	11	0	100	Do.
Clover	1-12	49	76	90	92	93	2	5	100	Oct. 3
Do	None.	58	80	88	90	90	2	8	100	Do.
Alfalfa	1-12	27	58	65	72	73	6	1	80	Oct. 4
Do	None.	17	50	64	71	74	5	1	80	Do.
Stellaria media	1-12	11	48	63	70	71	7	2	80	Oct. 5
Do	None.	18	47	62	65	69	10	1	80	Do.
Total	1-12	147	339	425	461	477	29	14	520	
Do	None.	154	359	423	454	473	35	12	520	

[1] Each experiment was begun at 5 p. m. Counts were made in the morning.

In the experiments recorded in Table 52 the larvae were given unrestricted choice between the succulent vegetation and one of the baits. If one of the baits had been less attractive than the other, the larvae would have chosen to consume the equally available green food to a greater extent in these units of the experiment than in the case of the more attractive bait, and this preference must have been indicated by the higher death rate favoring the more attractive material. An examination of the table shows that there is no substantial difference in the total number of larvae killed by the two baits at any period of the experiments and one is forced to the conclusion that the larvae had no preference for the sweetened bait.

An extensive series of experiments with various dosages of both Paris green and sirup without green food has not given evidence of the slightest increase in mortality in favor of the sweetened baits, and less extensive experiments with seven other arsenicals have given similar evidence in the main, although the results with potassium arsenite and potassium arsenate have been consistently in favor of the sweetened bait.

FIELD EXPERIMENTS

Morrill (*47*) gives a review of the history of the use of sweetening in poisoned baits, and after large-scale experiments with both sweetened and unsweetened baits and in view of the replies obtained to a questionnaire sent to the heads of State entomological departments, he concludes as follows:

> At the present time it may be considered as established that molasses or syrup of any kind is absolutely unnecessary as an ingredient of poisoned baits against many of the common cutworms. On the other hand some investigators have found that the addition of molasses increases the attractiveness of the bait to some species under certain conditions. * * * While the value

of the several ingredients in baits for use against grasshoppers is still a matter for investigation it seems most logical for entomologists to recommend the simple bran and Paris green, or bran-Paris green and water mixture against cutworms except when there is some definite reason for the addition of molasses, syrups or other ingredients.

Slingerland (*58*) as early as 1895, reporting the observations of Davis in Michigan, states that—

> * * * the sweetening did not add to the attractiveness of the mixture [bran bait] for the cutworms.

The writer's field experiments comparing sweetened and unsweetened baits have been made against *Feltia annexa*, *F. gladiaria*, *F. ducens*, *F. subgothica*, *Agrotis ypsilon*, *Euxoa messoria*, *Lycophotia saucia*, and *Prodenia ornithogalli*, and there is nothing in these experiments to indicate that any great preference for the sweetened bait exists in any of the above species.

In one of these experiments the species occurred in the following proportions: *Feltia ducens* 20 per cent, *Agrotis ypsilon* 35.5 per cent, *Lycophotia saucia* 39.1 per cent, and *Prodenia ornithogalli* 5.4 per cent. A bait consisting of bran, 50 pounds, Paris green, 1 pound, and water, 9 gallons, was applied to 7 rows in a heavily infested tobacco field; 6 rows next to these were left untreated; and another 7 rows next to these received an equal application of a bait identical with the above except for the addition of 2 quarts of corn sirup. An examination made five days later showed 32.7 per cent of the plants cut in the check plat and 7.7 per cent cut in both the sweetened and the unsweetened plats. Apparently the sweetened bait did not possess much superior attractiveness to any of the above species of cutworms.

In a tobacco field at Quincy, Fla., which was heavily infested with larvae of *Feltia annexa*, *Agrotis ypsilon*, and *Lycophotia saucia*, F. S. Chamberlin applied sweetened and unsweetened baits of the same formulas as given above except that 3 quarts of sirup was used. Two days after the bait was applied he found a mortality of 60 per cent in each plat.

The writer has also tested baits of the above formulas, varied by the use of 5 quarts of sirup in the sweetened bait, in a tobacco field infested by *Feltia gladiaria*, where the baits were applied at the rate of about 25 pounds per acre, and found 100 per cent of the larvae dead in both the sweetened and unsweetened plats three days after the application was made.

As indicated in Table 51, while cutworms were indifferent to fresh corn sirup under the conditions of these laboratory experiments, they responded strongly on the second day and thereafter when the bait became fragrant owing to the fermentation of the sirup. One field experiment had for its object the determination of whether or not this undoubted attractiveness of fermented sirup to cutworms would have any influence on the effectiveness of the bait in the field. The unflavored bait consisted of bran, 50 pounds; Paris green, 1 pound; and water, 9 gallons; the sweetened bait was of the same formula but for the addition of 3 quarts of sirup. This sirup was from some old stock which had been left open at the laboratory and which had become very fragrant through fermentation. These baits were applied at the rate of 25 pounds per acre in plats alongside of one another and very careful examination three days later gave a mortality of 100 per cent for each plat.

Eight species of cutworms have been included in field experiments and the unflavored bait has been uniformly as effective as the flavored bait. A long series of laboratory experiments has likewise failed to give any indication of superiority in the sweetened baits. The writer does not feel that the use of sweetening in baits for the control of any species of cutworms is justifiable until the desirability of such ingredient has been established by field experiments.

Citrus Fruits in Baits

As shown in Table 51, lemon juice, lemon peel, oil of orange peel, and citral were not at all attractive to cutworms under the conditions of the experiments there recorded. Citric acid may have been faintly attractive.

In field experiments two baits were applied, each at the rate of 10 pounds per acre, in contiguous plats in which cutworms occurred at the rate of about 1,000 larvae per acre. The first bait consisted of wheat bran, 25 pounds; Paris green, 1 pound; sirup, 2 quarts; lemons, 6; and water, 4.5 gallons; and the second bait was identical with the first except that the lemons were omitted. The bait containing lemons was applied one day before the other and this last bait was leached and mixed with earth by a fall of 0.66 inch of rain, beginning about 7 p. m. of the evening of application. The results in the two plats were followed very closely. The citrus bait killed about 70 per cent of the larvae in 2 days and 93 per cent in 8 days, while the bait from which the lemons were omitted killed about 60 per cent of the larvae in 2 days and 85 per cent in 7 days, the inferiority of the second bait being no greater than might be reasonably ascribed to the unsatisfactory conditions under which this bait operated from the beginning.

Strickland (*69*) states, with regard to the use of fruit juice in poisoned baits:

> Though this is apparently a valuable material when added to grasshopper baits, it has not proven to be of appreciable value when utilized for the control of prairie-inhabiting cutworms.

Berger (*4*) has also observed that citrus fruits are not a necessary ingredient in baits against *Prodenia eridania*. The writer's experiments, including most of the common species of cutworms found in the eastern States, give no evidence that citrus fruits are of any value in poisoned baits against any of these species.

PREPARATION AND APPLICATION OF BAITS

Preparation of Bran Bait

The bran and poison should be thoroughly mixed dry in a tub or other suitable vessel and gradually moistened and thoroughly mixed with water. The hands are the best instruments for this preparation, and there is little danger in thus preparing a few hundred pounds of bait if reasonable care is taken to avoid breathing the poisoned dust and the hands and arms are washed several times in a portion of the water used. The amount of water added to the bran depends upon the character of the bran and should not be such that the bait will drip when squeezed in the hand. It is probable that a moist bait will prove slightly more effective on a dry soil than a comparatively dry bait.

Moistened or Dry Baits

Sirrine reports (*56*) that onion growers in New York used dry unsweetened bran poisoned with Paris green in the control of larvae of *Euxoa messoria* and that the dry bait was as attractive as a moistened one and was effective over a longer period. This preference for the dry bait is also voiced by a correspondent in the Rural New-Yorker for June 24, 1911. In spite of this satisfactory use of the dry bait, it has been the writer's observation and the experience of various workers that the moistened bran is decidedly more attractive than the dry article. The failure of the bran bait in arid regions is largely ascribed to its relative unattractiveness when dry, and the dry bait certainly must become moistened by contact with moist soil or by dew before it becomes fully effective. The dry bait is also open to the objection that a considerable portion of the poison becomes detached from the carrier and is carried away by the wind in the process of application.

Poisoned Vegetation as Bait

Vegetation may be used as a bait where attractive field crops, such as clover or alfalfa or such weeds as chickweed, dock, or plantains, are obtainable at the time tobacco is being set. This green food may be poisoned by placing it in piles which are moistened and then turned on a clean surface as the poison is dusted over them. This material is then loaded upon a wagon and distributed in small bunches or sprigs preferably late in the day in order that the vegetation may be fresh at the time cutworms become active. The use of vegetation in this way very materially increases the labor cost of control as compared with that incurred in an application of bran bait, particularly when it is necessary to collect the green food by hand.

This material will probably give unsatisfactory results when used for the protection of plants already set in the field, since the tobacco will prove more attractive than the poisoned food, and this will be especially true in case a too concentrated dosage of poison has been applied. The most satisfactory results will be obtained by the distribution of this poisoned green food in small compact bunches in the infested field some days before setting the plants or by scattering it in prepared ditches in which the moving larvae have become concentrated.

Methods of Application

The writer has carried out two series of experiments in an effort to determine the relative efficiency of broadcasting and hill application of baits, but the results have contained such contradictory elements that these experiments do not furnish satisfactory evidence on the point desired. The hill applications at the rate of 10 pounds per acre have shown a higher percentage of larvae dead on the second day after application than were found in the areas broadcasted at the rate of 35 pounds per acre, and when the live larvae found in the respective plats have been brought to the laboratory and fed on unpoisoned food the mortality has still been much higher in the larvae from the hill applications. But in spite of these evidences of the superiority of the hill applications, only about half as many plants have been injured in each case in the broadcasted areas as were injured in the other.

The writer's observations on a large number of hill applications show that this method of applying the poisoned bait gives very satisfactory results in cases of moderate infestation. Broadcasting might give somewhat better protection to plants even in moderate infestation but there could scarcely be sufficient difference between the results in the two applications to warrant a broadcasting of more than 12 pounds of the bait per acre where a 10-pound hill treatment would suffice. In severe infestations broadcasting at the rate of 15 or 20 pounds per acre should be employed. An application of 10 pounds of bait to 3,600 plants (1 acre) allows only a pinch at each hill, and a fairly uniform broadcast application at the rate of 15 pounds per acre is scarcely discernible on the ground. Some experience is required for the proper dissemination of so small a quantity of bait per acre. It is preferable that the bait be distributed late in the evening in order that it may be fresh and moist when cutworms become active.

In making the application the writer has merely carried a bucket filled with the bait on the left arm, walked fast, and dropped a small quantity, two rows at a time, near but not upon or against each tobacco plant. Where the broadcast method of application is resorted to a variety of mechanical aids may be employed to insure a quicker and cheaper application. Cooley and Parker (*17*) state:

> It [the bait] can be distributed very rapidly from the rear of a light wagon. A good plan is to start with several barrels of the prepared mash in the forward end of the wagon. Shovel about 25 pounds of the mash into a box resting on a waist-high platform at the rear end. Then a person standing in front of the box can easily and rapidly distribute the mash as the outfit is driven over the field.

Urbahns (*76*) attains a like result through the use of an end-gait grain seeder, and probably a broadcast hand seeder might be employed for the same purpose.

Treatment of Plant Beds

The writer has found that an application of poisoned bran bait at the rate of 4 pounds (dry weight) to 100 square yards of bed has given excellent results in the protection of seedling tobacco plants. Beds treated with the bait at the above rate have produced a fine crop of plants where adjacent untreated beds have been eaten bare by the larvae of *Lycophotia saucia.*

OTHER CONTROL METHODS

FALL PLOWING

The writer believes that late fall plowing as a measure for the control of cutworms is of doubtful utility under the conditions prevailing in northern Tennessee. Plowing the latter part of October in this latitude will kill a large percentage of the overwintering pupae if the soil is friable. But this has but an indirect and minor bearing on the number of larvae which will be present when the tobacco is set the following spring, and most of the pupae, in the absence of plowing, are killed during the winter by climatic conditions, since this is a very inefficient overwintering stage.

Control of overwintering larvae by late fall plowing is not practicable under usual conditions, since these hardy larvae, after attaining a little growth, are able to eke out an existence on the vegetation turned under by the plow until the crop spouts or weed seedlings make their appearance, as the writer has learned through observations on conditions in the spring in plowed fields.

Probably the most effective time to plow for the elimination of cutworms is before the eggs are laid or while the larvae are very small. This period extends to about the middle of September in this latitude. It is probable, however, that the untoward conditions enforced upon the predatory enemies of the cutworms in plowed fields go far toward counterbalancing the good derived from this practice. In any case fall plowing will not insure a field against infestation the following spring if attractive vegetation appears in it, since moths will then be attracted to this area for oviposition.

DITCHING

Ditching is resorted to when cutworms occur in very great numbers either as invading armies or in land at the time of plowing. The writer has had no experience with infestations of this character, and the following recommendations are drawn chiefly from the writings of Strickland (*68*).

The ditches are of two types, the vertical-sided ditch in moist soil and the dusty-sided ditch in dry soil. In the first type, when used as a marginal barrier, the furrow is thrown away from the field to be protected and it may be necessary to deepen it by running the plow through a second time, throwing the soil in the same direction as before. A coulter is used in order that the margin of the furrow next the field may be as sharp and vertical as possible and this margin may require reshaping with a spade to be most effective. In the dusty-sided ditch a deep furrow is plowed with the earth thrown toward the field to be protected and a log is ridden up and down the furrow, preferably shortly after plowing, until the sides are composed of such loose fine soil that cutworms have great difficulty in scaling the slope. Similar ditches may be made at intervals across grossly infested plowed fields, but the eradication of cutworms by means of ditches is very largely dependent in this case on the elimination of all green food in order that the larvae may be induced to wander and thus fall into the ditches, in which they are poisoned.

An excessive labor cost is usually entailed in the construction of a ditch which will act as a permanent barrier against an army of cutworms. Post holes made at intervals in the bottom of the ditch trap many larvae, but the main virtue of an ordinary ditch is that the larvae by this means may be induced to pause long enough to become sensible of the presence of poisoned bait strewed in the furrow. When their march is not impeded, most of the larvae under some circumstances will pass over the bait without feeding, and the ditch application of bait, in any case, gives the largest return for the quantity of bait used. The application, whether of poisoned shorts or bran or of poisoned vegetation, should be made at the rate of 10 pounds to about 60 rods of trench. In case the larvae are exceedingly numerous, a second ditch some yards within the other may be prepared and strewed with bait if larvae succeed in reaching it in large numbers.

With regard to the effectiveness of ditching Strickland (*68*) states:

It cannot be claimed that this method of poisoning in furrows will kill all of the larvae upon a field, for some will not enter the furrows at all, and a certain percentage of those that do will escape. It is claimed, however, that for the money expended it gives greater benefits than does any other method with which we have been able to experiment. Upon the field through which we plowed the furrow that killed over three million larvae to the mile, the larvae which escaped were not sufficiently numerous to cause appreciable damage.

Cooley and Parker (*17*) also state, in regard to an experiment carried out by them:

All the worms that could be found (on the morning following the application) were gathered from an area of 4 square feet in the treated strip outside the furrow. Ninety dead and 155 live worms were found. Many of those alive were too sick to curl up when touched, and the owner of the field said later that nearly all were dead the following day. The advance of the worms was stopped immediately and no further injury resulted. The owner expressed himself as satisfied that the treatment had saved him from the expense of reseeding the entire field.

USE OF LIGHT TRAPS

Light traps are not practicable for several reasons.

(1) A very small percentage of the moths taken, probably under 10 per cent on the average, are females which have not already nearly or quite completed oviposition.

Slingerland (*58*) found that of 2,382 adults of *Feltia ducens* taken in light traps, 6 per cent were females; and 31 adults of *F. subgothica* showed 29 per cent females. Turner (*72*) records that of 2,816 adults of the genus Feltia taken in a light trap, 28.3 per cent were females; of 202 moths of *Agrotis c-nigrum*, 53 per cent were females; and of 269 moths of *Polia renigera*, 28.6 per cent were females. In the writer's experiments 1,144 moths, including *Feltia ducens* and *F. subgothica*, were 8 per cent females; 605 moths of *F. gladiaria* were 3.3 per cent females; and 177 adults of *Agrotis badinodis* gave no females.

Of the above-mentioned 7,626 cutworm moths taken in light traps, 1,244, or 16.3 per cent, were females. Taking the percentages of females in the different species, the average is found to be 19.5 per cent. In the experiments carried out by Turner the moths represent the total catch of cutworm-producing species at one light for one season. The totals in the writer's experiments represent practically the entire catch at one light for three seasons.

(2) One or more broods of moths must have reproduced successfully, with consequent injury from the larvae, before light traps take moths in considerable numbers, and only a small percentage of the moths occurring in a region are attracted to lights.

Through a survey of the number of larvae occurring in various types of cover and through rearing larvae under natural conditions and keeping a record of the number emerging, the writer has learned that at least 200,000 moths of *Feltia ducens* and *F. subgothica* emerged within one-fourth of a mile of the trap light at Clarksville during the three years the trap was run. Of this number 1,144 moths, or about 0.6 per cent, were attracted to the trap light, which consisted of an electric bulb of from 60 to 200 candle power in connection with an efficient trap.

(3) Poisoned baits attract the destructive stage of the insect, and control by this means is decidedly cheaper than that secured by light traps.

The only recorded experiments with light traps on a commercial scale known to the writer are those conducted by Bensel (*3*). With eight 1,000-candle power electric arc lights and 24 smaller light traps 1,000,000 moths of *Lycophotia saucia* were taken at a cost of about $250. He secured no data as to the percentage of females taken, but states that Graf in the previous year found that 22 per cent of the females taken had not already completed oviposition. In the cutworm-producing species recorded in paragraph (1) above it was found that the average percentage of females was 19.5. If one may consider that this percentage also applies to *Lycophotia saucia* under the conditions of the above experiments by Bensel, 195,000 females were taken by him, of which 42,900 (22 per cent) had not completed oviposition.

In case each of the above 42,900 moths deposited 800 eggs and every larva survived, there would be sufficient cutworms to allow four to each square foot over 200 acres. Thus, upon the above suppositions, trapping may be said to have prevented an infestation of this degree over 200 acres at a cost of $250. If it is to be supposed that the moths were taken from an area much greater than 200 acres, the control exercised becomes too diffused to be of appreciable service. But an unsweetened poisoned-bran bait could be applied over the above area at the rate of 15 pounds per acre at a total cost for materials and application of somewhat less than $100.

(4) Where protection from cutworms is sought by trapping the parent moths, no advantage is taken of the well-known fact that natural agencies frequently intervene and suppress potential outbreaks of insects, particularly after the species has been abnormally abundant for a time. With baits action is taken only when the danger is imminent.

(5) About as many friends as foes are destroyed in light traps. Slingerland (*59*), reporting on the results obtained with six trap lanterns in which nearly 13,000 insects were taken, states:

> The percentage (10.4 per cent) of decidedly beneficial insects killed, nearly equals that of the species which are "often pests" (12.6 per cent). And the important fact that one beneficial insect usually kills several injurious ones must be considered in this connection.

USE OF BAITED TRAPS

The writer's experiments with baited traps for capturing cutworm-producing moths have mostly been made with ordinary cylindrical wire-screen flytraps about a foot high and set on legs 2 inches high. These traps were placed on boards nailed to the tops of stakes 2 feet high. The best baits tried were fermenting fruits. Most of the moths recorded below were taken in September and October, 1916. The record of the number and sex of the adults captured is as follows: *Feltia gladiaria*, 18 moths, 50 per cent females; *F. ducens* and *sub-*

gothica, 74 moths, 33.8 per cent females; *Noctua badinodis*, 174 moths, 14.4 per cent females; *Polia renigera*, 200 moths, 54.5 per cent females; *Agrotis ypsilon*, 269 moths, 54.7 per cent females; *Lycophotia saucia*, 10 moths, 90 per cent females; and *Prodenia ornithogalli*, 22 moths, 54.5 per cent females.

Of the above 767 moths taken in bait traps, 336 or 43.8 per cent were females, as compared with 16.3 per cent females in the light-trap captures. The baits lure more females than the lights, and it has been the writer's impression that a decidedly greater proportion of egg-bearing females are taken in bait traps than are caught at lights, although he has no data on this point.

The following substances have been tested with regard to their ability to attract moths to traps: Beer, corn sirup, vinegar, and water solutions of methyl acetate 4 per cent, amyl nitrate 4 per cent, acetic acid 10 per cent, acetaldehyde 10 per cent, and ethyl alcohol 10 per cent. The beer and the vinegar each took a few moths, the other substances none. The experiments were run for 11 days during October, 1915. Moths of 12 cutworm-producing species were being taken in the same kind of traps when baited with fermenting fruits at the time the above materials were being tested.

The writer has had no marked success in attracting cutworm moths to baited traps, although he has used types embodying the principle of the Andres-Maire trap described below, and little attention has been given to this subject in the United States. However, in the chaur lands of India, in which *Agrotis ypsilon* is a very serious pest, the trapping of the moths by the use of a proprietary bait has been found to be the most satisfactory method of control. The trap used is known as the Andres-Maire moth trap and is described (in part) by Woodhouse and Dutt (*84*) as follows:

> The traps are raised some four feet off the ground in order to increase the distance to which the scent of the attractive liquid is carried. The four sides of the trap each consist of six sloping platforms of wire gauze, the underside of which is horizontal. The moths walk up the projecting platform and enter the trap by a narrow slit between it and the horizontal portion of the platform above.

It is important that the slit should not exceed one-third inch in breadth. The attractant is exposed on gunny bands within the trap. It is estimated that only about 1 moth in 200 escapes from the trap.

MANIPULATION OF NATURAL AGENCIES

Some kinds of birds play an important part in the control of cutworms and deserve protection and encouragement, but the most interesting and probably the most fruitful field of effort, in the manipulation of natural agencies for cutworm control, lies among the diseases and insect parasites of these insects. Disease would seem to be especially well fitted for such service under the control of man, but has generally proven of uncertain value when so employed, owing to certain strict limitations of the causal organisms and probably also owing to our ignorance of the nature of some of these limitations.

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